ESTCP
Cost and Performance Report

(RC-200609)

Validation and Development of a Certification Program for Using K9s to Survey Desert Tortoises

August 2011

ENVIRONMENTAL SECURITY
TECHNOLOGY CERTIFICATION PROGRAM

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ACRONYMS AND ABBREVIATIONS

ACUC	Animal Care and Use Committee
ARO	Army Research Office
BLM	Bureau of Land Management
CESA	California Endangered Species Act
CV	curriculum vitae
DoD	Department of Defense
DRI	Desert Research Institute
DTCC	Desert Tortoise Conservation Center
DTK9	Desert Tortoise Canine
DWMA	Desert Wildlife Management Area
EAFB	Edwards Air Force Base
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
FISS	Fort Irwin Study Site
GIS	geographic information system
GPS	Global Positioning System
GSD	German shepherd dog
LDS	line distance sampling
MCL	median carapace length
MOG	Management Oversight Group
NAC	Nevada Administrative Code
NTC	National Training Center
PI	Principal Investigator
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator

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This demonstration was a collaborative effort among the scientific investigators, the master trainer, the dog handlers, and field technicians. The unique contributions made by each and all of the demonstration team members enabled this work to continue through to its final success. The diversity of each individual's professional backgrounds enriched the demonstration in countless measures over the course of successive field seasons.

Dr. Russell S. Harmon of the Army Research Office (ARO) provided the mechanism for funding this work, technical guidance, and program support. Without his efforts and interest in the promise of DTK9 teams to meet the needs of the military and partnering agencies, this demonstration would not have been possible.

Co-performers of the U.S. Geological Survey (USGS) on this demonstration were Dr. Kenneth Nussear and Dr. Todd Esque. Their willingness to participate in seeking part of a solution for current conservation issues for the Mojave Desert tortoise was significant. Their role in managing the field technicians supporting the DTK9 teams is also acknowledged. Master Trainer Cindee Valentin integrated the language of "dogs and handlers" into the scientific process. She ensured tortoise safety every time dogs and tortoises interfaced. Her expertise, guidance, and professionalism resulted in significant contributions to our understanding of detection and specifically wildlife detection. Although not a scientist, her role on the scientific team was critical towards accomplishing the demonstration objectives.

We would like to acknowledge the following dog handlers who participated in one or more of the demonstrations with their dogs: Aimee Hurt with Finney and Wicket, Margaret "Tudy" Morris and Storm, John Rarity and Kai, Chris Salisbury and Denali, Meaghan Thacker and Nandi, Laura Totis and Sammy, Alice Whitelaw and Camas, and Kristin Winford and Tango. Many field technicians worked alongside handlers and Principal Investigators (PI) alike and we acknowledge their efforts: Aaron Bevill, Phillip Chalker, Hannah Converse, Paul Cossman, Kristina Drake, Peter Graham, Jordan Harrison, Allison Hawkins, Brian Jacobs, Jennifer Oliphant, Claire Phillips, Melissa Rosenberg, Emily Roskam, Michelle Sargent, Peter Van Linn, and Carrie Walters.

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The demonstration was conducted at multiple sites, and we would like to thank Mr. Mickey Quillman for his support at the National Training Center (NTC) Fort Irwin and the Fort Irwin Study Site (FISS). Dr. Kenneth Nagy and Scott Hillard, both from the University of California Los Angeles, provided our research team access to their research tortoises at FISS. Scott also provided valuable field assistance and technical guidance on small tortoise transmittering. Michelle McDermott managed the Desert Tortoise Conservation Center (DTCC) for much of the time we conducted training and testing activities with the dog teams at DTCC, and her efforts to provide us with the resources necessary to conduct the work were invaluable. Gerald Hickman allowed us to use Bureau of Reclamation lands for the low density portion of our evaluation procedures.

Dr. Jill S. Heaton of the University of Nevada Reno contributed technical assistance and personnel early in the demonstration. Dr. Susan Clark played a critical role in integrating the team members who came together from different disciplinary backgrounds. She worked to ensure that the training protocols ran at maximum efficiency and was able to help translate Cindee Valentin's process in a meaningful way to both handlers and scientists. Lisa Wable of the Desert Research Institute (DRI) provided technical assistance, particularly with graphics, in this report.

1.0 EXECUTIVE SUMMARY

1.1 OBJECTIVES OF THE DEMONSTRATION

This project demonstrated the ability of Desert Tortoise Canine (DTK9) teams to locate Mojave Desert tortoises in the field at natural population densities, with an emphasis on finding small size classes. DTK9s were shown to be successful at this task. DTK9 team technology was developed to assist Department of Defense (DoD) installations and other agencies to maintain environmental compliance and support delisting efforts for the federal and state listed Mojave Desert tortoise (*Gopherus agassizii*). Delisting the desert tortoise would alleviate conflict between training and testing on installations and environmental regulations. Delisting would reduce costs associated with regulatory compliance such as surveying, monitoring, translocation, and Head Start programs.

The benefits of DTK9 teams over current practices to survey for Mojave Desert tortoises include demonstrated ability to locate the full range of size classes and in particular small animals, a greater find rate for tortoises in certain configurations, efficiency in survey area coverage, and cost. Currently, desert tortoise surveys are conducted by humans using visual methods such as mirrors and probe poles. Humans have not returned reliable find rates for tortoises smaller than 180 mm median carapace length (MCL), and thus current range-wide surveys conducted by U.S. Fish and Wildlife Service (USFWS) do not include data on the smaller animals. Studies comparable to RC-200609 for human detection capability remain outstanding.

Performance objectives were evaluated in each of two phases conducted in southern Nevada: Phase I was baseline characterization at the Desert Tortoise Conservation Center (DTCC), and Phase II was the field demonstration at Piute Valley. The objective of Phase I was to demonstrate that DTK9 teams can pass a testing regime that assesses their capability at finding tortoises under both high and low tortoise density scenarios with tortoise safety maintained throughout. Phase II demonstrated that teams deemed qualified to conduct field searches for tortoises based on meeting Phase I testing criteria performed similarly in the field, while those teams that failed to meet the testing criteria did not perform to standard in the field. Performance objectives were met, and in some cases performance exceeded the criteria.

1.2 TECHNOLOGY DESCRIPTION

The use of dogs to assist humans has a long history, particularly with the U.S military. The U.S. military has played and continues to play an active role in developing working dog applications, particularly for detection. Recent dog detection advancements for military and homeland security applications include improvised explosive devices and identifying humans that have been in contact with bomb-making materials or wear explosive devices. The DTK9 program drew upon this type of training applied to non-lethal targets. Dogs use olfaction to detect desert tortoises, which lends an orthogonal approach to visual methods currently employed in surveys. They can be trained to sniff and alert on odors within their threshold of detection, including live animals. The demonstration design established DTK9 capability by comparing results from field survey deployments against baseline assessments. Deployment parameters and a certification standard for DTK9 teams were also established.

1.3 DEMONSTRATION RESULTS

Phase I included three different tests—safety, high density tortoise scenario, and low density tortoise scenario. Quantitative metrics included threshold scores for safety, based on nine different behaviors, and for efficacy and reliability. Behavioral measures of safety included aggression (defensive and overt), excessive flight, play interaction, growling, barking, stalking, excessive focus and inability to relax in the presence of or aimed directly at tortoises. Efficacy is the number of targets (e.g., tortoises) found of the total available to be found. Reliability is the number of trained alerts performed by the dog divided by the total number of targets found. Both metrics are calculated based on the first encounter with a particular tortoise. Taken together, efficacy and reliability are a capability metric of a team. For the high density scenario, a minimum efficacy of 70% and minimum reliability of 75% were required. For the low density scenario, the teams were scored as pass/fail. Handlers were required to maintain safety at all times for all tests and were required to use the in-field calibration method we termed "Read-and-Go." All teams passed the safety test. Six of the seven teams passed the high density scenario and six passed the low density scenario. In total, five teams passed all three assessments and two teams failed the testing criteria.

All teams were then fielded for the Phase II demonstration that was conducted on a population of wild, transmittered desert tortoises supplemented with transmittered small tortoises in Piute Valley, Nevada, in desert tortoise critical habitat. Teams were not informed of their testing results and believed they had all passed. This was done to minimize handler belief bias in the field demonstration. Performance assessment was based on finding three size classes of tortoises: small (<110 mm MCL), medium (110–180 mm MCL) and large (>180 mm MCL). The required efficacies to pass the assessment for these classes were 50%, 60%, and 70%, respectively with reliability of 75% for all size classes. The five teams that passed Phase I tests yielded 78% (small), 96% (medium), and 100% (large) efficacy and 90% reliability. The two teams that failed Phase I yielded 14% (small), 50% (medium), and 75% (large) efficacy and 55% reliability.

The testing procedures implemented in Phase I resulted in producing teams that were capable of safely and successfully surveying for desert tortoises in natural field conditions, across all size classes at expected natural densities. It was also demonstrated that the testing procedures in Phase I would have eliminated teams that did not perform to required standards in the field environment. Thus the testing procedures were valid and relevant in relation to the program goals.

1.4 IMPLEMENTATION ISSUES

Implementation of DTK9 teams rests in part on acceptance of the proposed certification standard by the federal and state regulatory (permitting) agencies. Discussion and review of the standards are ongoing with these agencies. Once the process is approved, the use of DTK9 teams can be implemented in the same manner as for human surveys. Contractors are expected to provide the primary source of DTK9 teams; however, DoD installations could easily develop in-house capabilities given the widespread acceptance and use of dogs for other military applications.

2.0 INTRODUCTION

2.1 BACKGROUND

DoD installations in the Mojave Desert face conflict between installation mission (e.g., training and testing) and environmental compliance with regard to the federally (USFWS, 1990) and state listed (Nevada Administrative Code [NAC] 503.080), California Endangered Species Act (CESA) Fish and Game Code §§2050, et seq. Mojave Desert tortoise, *Gopherus agassizii* (Figure 1). Military operations are identified as one of the threats impacting tortoise populations in the 1994 Recovery Plan (USFWS, 1994; Boarman, 2001). The desert tortoise has low annual fecundity over a long lifespan with low and variable egg and hatchling survival (Wilbur and Morin, 1988; Congdon and Gibbons, 1990; USFWS, 2008). There is a gap in the knowledge base about desert tortoises because the smaller size/age cohorts are relatively unstudied and are difficult to locate during typical survey efforts. As long as desert tortoises are afforded legal protection, DoD will be required to comply with requirements set forth by USFWS Biological Opinions for individual installations. This compliance comes at significant monetary cost and can alter military training and testing to avoid physical contact with tortoises and habitat destruction.

Figure 1. Mojave desert tortoise (*Gopherus agassizii*).

To support meeting mission goals in compliance with environmental law, DoD participates in desert tortoise density surveys as well as clearance surveys as part of translocations of tortoises from military lands to other public lands. Desert tortoise habitat is currently surveyed by various methods involving humans using visual detection methods to find tortoises. Smaller size classes of tortoises are so infrequently encountered by these surveys that they are omitted from analysis

under current range-wide monitoring efforts (USFWS, 2010a). Figure 2 depicts one reason that the smallest tortoises can be difficult to locate. Small tortoises are able to exploit mammalian burrow complexes such as the one shown. Observing a tortoise in such burrow complexes is difficult with visual methods. The line distance sampling (LDS) method currently used for range-wide surveys of desert tortoises does not require that surveyors find all tortoises, only that they find all tortoises on a defined survey line (USFWS, 2011). Analysis of range-wide survey data has shown that training improves a person's ability to see tortoises, and with training humans can find a high percentage of both adult (290 mm MCL) and sub-adult (180 mm MCL) sized models (USFWS, 2006; USFWS, 2010a), yet numbers from the field yield few observations of smaller animals.

Figure 2. Small tortoises are able to exploit mammalian burrows such as the one shown.

Detection of a stable or upward population trend is the first criteria required for delisting of this species and the projected rates of recovery under ideal conditions may be as slow as 1% per year (USFWS, 1994; USFWS, 2008). Detection of trends of this magnitude requires precise methods of density estimation (Nussear and Tracy, 2007) and the new recovery plan calls for demographic study plots to be monitored for trends in population demographics (USFWS, 2008). At present, the causes of desert tortoise population declines are linked to threats primarily associated with human land uses; however, little data are available to support the effects of specific stressors (Tracy et al., 2004) or quantify the effects of threats on populations. It is widely recognized that a deficit exists for data on smaller size classes of tortoises and, as a consequence, also on demographic processes (USFWS, 1994; Doak et al., 1994; Tracy et al., 2004; USFWS, 2008). This is largely due to the difficulty in detecting these individuals in the field. Additional demographic data would be useful in determining which of several possible threats may be

impacting specific life stages of desert tortoise populations in a given area, and therefore guide management on where to focus conservation efforts in support of strategic recovery elements. It is unlikely that the desert tortoise will be delisted without a better understanding of its population demographics and how population distributions change over time, determined through monitoring. A sound demographic analysis of desert tortoise populations must include data on small desert tortoises, including recaptures of marked individuals over time (Figure 3).

Figure 3. Authorized tortoise biologists attach a transmitter to an adult tortoise. A tortoise is marked with each successive capture for mark-recapture studies.

The technical barrier the DoD faces in maintaining compliance with federal laws regarding desert tortoise population monitoring is rooted in the same challenges. For the DoD having an accurate means of finding small tortoises (Figure 4) not only offers a means of improving the efficacy of clearance work, but also offers the potential for an improved means for government land managers to conduct long-term monitoring of desert tortoise populations in discrete locations with specific emphasis on smaller size classes of tortoises. This type of data collection would also support strategic elements identified in the revised Recovery Plan (USFWS, 2008) designed to improve the 1994 Recovery Plan.

Delisting the tortoise is an important issue for DoD installations that have desert tortoises and their habitat due to the expense in funds, time, resources, and interruptions to training or testing that result when a tortoise is encountered during military activities. Recent analysis of range-wide monitoring data shows that the highest densities of Mojave Desert tortoises were reported on DoD land in the Eastern Colorado recovery unit on the Chocolate Mountain Air Gunnery Range; sampling data are reported separately for DoD land in this recovery unit (USFWS, 2010a). The cost of recovery is substantial. The USFWS estimated the cost of recovery for Mojave Desert tortoise to be a minimum of $159,000,000 (USFWS, 2008).

Figure 4. A hatchling desert tortoise with GPS Garmin eTrex Legend for scale.

RC-200609 was undertaken to meet the needs of the military through improved data collection that support environmental regulatory compliance directly, via improved survey methods, and indirectly in efforts to support delisting the Mojave desert tortoise. This was accomplished using dog teams trained to find live desert tortoises, termed “DTK9s.” A DTK9 team is defined as one dog with one handler. DTK9s are trained to find live desert tortoises. The use of DTK9 teams was developed as a proof-of-concept for the U.S. Army in 2004 and 2005. Results of that work yielded estimates of the capability of dog teams to locate adult desert tortoises and compared detection rates for adult tortoises by DTK9s to human search teams. RC-200609 completed the development of testing to qualify DTK9 teams and validated their capability to locate desert tortoises of all size classes in the field at natural population densities, in three microhabitat configurations (underground, on the surface in vegetation, and on the surface in the open), with an emphasis on finding small desert tortoises. DTK9s were successful at this task.

The increased detectability achieved by using DTK9s to locate small desert tortoises could enhance the current capability to quantify population parameters and could improve the ability to detect and model future population trends. This more complete information of desert tortoise

populations would be a major step forward for land managers who are responsible for directing and focusing conservation efforts. The first two Recovery Objectives of the revised Recovery Plan are demography and distribution (USFWS, 2008). Based on the success of this demonstration it is anticipated that DTK9s may provide a means of gathering currently unavailable data. These data could greatly expand the knowledge base of desert tortoise demography and also could offer a way of detecting subtle population trends for a broader range of size classes of animals than presently possible. These studies are recommended in the original Recovery Plan (USFWS 1994) and the Recovery Plan Assessment (Tracy et al., 2004) and are a major focus in the revised Recovery Plan (USFWS, 2008).

2.2 OBJECTIVES OF THE DEMONSTRATION

The overarching objective of RC-200609 was to demonstrate the utility of a new technology useful to survey for Mojave Desert tortoises that enables detection of the smallest size classes. In support of this, RC-200609 demonstrated that DTK9 teams can effectively find a complete demographic of desert tortoises at natural population densities in desert tortoise habitat under realistic survey conditions. In addition, the demonstration established deployment parameters including a test to certify safe, effective teams. This new approach to surveying desert tortoises using DTK9 teams has the potential to address the critical deficiency of the current survey method and would support management objectives on military installations that harbor desert tortoises and is focused on environmental regulatory compliance.

The performance objectives were established to demonstrate that DTK9 teams could pass a three stage testing regime designed to simulate actual field conditions while maintaining safety to tortoises at all times (Phase I) and that the testing regime was adequate in that those teams that passed these tests proved capable under natural survey conditions while those teams that did not pass the tests did not prove capable under natural survey conditions (Phase II). Performance objectives were met. The results of the demonstration validated that teams that passed the Phase I baseline assessment went on to perform equally or better under actual survey conditions and that teams failing this baseline were found to be ineffective. DTK9 teams were shown to be able to operate safely. The certification test developed as a prerequisite qualification for federal and state agency permitting was thus validated to identify capable and safe DTK9 teams, while excluding those teams that would not be capable of producing accurate survey results. Under natural working conditions in desert tortoise habitat, certified DTK9 teams were also validated to be able to locate a full range of size classes of desert tortoises, including hatchlings and juveniles in all configurations (surface, subsurface, shrub). Deployment parameters were established.

2.3 REGULATORY DRIVERS

The regulations governing desert tortoise protection apply at multiple spatial scales, including range-wide (i.e., throughout the entire range of the Mojave Desert tortoise population, which includes portions of four states), regional, and local. At a range-wide level, military installations are governed by the Endangered Species Act (ESA) and recovery actions are recommended in the USFWS Desert Tortoise Recovery Plan (USFWS, 2008). Regionally, the National Training Center (NTC) Fort Irwin, Edwards Air Force Base (EAFB), the Naval Air Warfare Center Weapons Division at China Lake, and the Marine Corps Air Ground Combat Center fall under CESA. Locally there are two USFWS Biological Opinions related to the desert tortoise that

apply to NTC Fort Irwin, one that governs its daily operations in the cantonment and training areas and a second governing actions related to the new expansion areas. In addition to the federal ESA, which protects Mojave desert tortoises range-wide, they are also protected by the CESA, the State of Nevada Department of Conservation and Natural Resources, the Arizona Department of Game and Fish, and the Utah Division of Wildlife Resources. Local administrative units of the U.S. Bureau of Land Management (BLM), U.S. National Park Service, U.S. Department of Energy, and DoD all regulate activities to provide protection of the desert tortoise and its critical habitat (Figure 5).

Figure 5. The DoD regulates activities to provide protection of the Mojave Desert tortoise and tortoise critical habitat.

Responsibility for implementing recovery actions is shared among the land managers in the Mojave Desert, and DoD plays an active role in stewardship. Officials from each branch of the U.S. Armed Forces with installations containing desert tortoises participate in the Desert Tortoise Management Oversight Group (MOG), established in 1988, along with other federal, state, county, and tribal agencies. The MOG plays a leadership role in coordinating activities of management agencies in support of implementing the recovery plan (USFWS, 2008). The ultimate delisting of the desert tortoise from the ESA is a responsibility shared among federal land managers. Under current policy, the delisting of the desert tortoise can only occur at a range-wide scale, not for individual populations or for selected areas. While it is important to comply with regional and local regulatory restrictions, delisting of the desert tortoise is unlikely if all affected parties limit their efforts solely to these activities. The DTK9 technology presented here potentially supports the call for improvements on how desert tortoises are surveyed, demographic modeling (USFWS, 1994; Tracy et al., 2004; USFWS, 2008), population

distribution and monitoring, and may provide an ability to better detect population demographic trends.

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3.0 TECHNOLOGY/METHODOLOGY DESCRIPTION

3.1 OVERVIEW OF DTK9 TEAMS

The technology is a highly sophisticated biosensor that has a history of use for other target applications modified and reworked to meet a strict set of requirements to comply with federal and state regulations—working dogs trained to locate desert tortoises. A DTK9 team is one dog and one handler. Because handlers are not expected to be in direct contact with tortoises, an authorized tortoise biologist will likely accompany a DTK9 team (Figure 6).

Figure 6. A DTK9 team is one dog and one handler although additional field personnel may be assigned to a DTK9 team as needed by the survey type and conditions.

Properly trained and certified DTK9s are able to find tortoises that occupy a variety of different and sometimes complex microhabitats (e.g., on the surface, under shrubs, and in burrows) even when they are effectively invisible to human observers. This level of detection is possible because dogs largely depend on olfaction to guide them to the tortoise. The use of odor recognition, rather than visual cues, provides an orthogonal detection tool.

Olfaction is the sensory perception that is least understood scientifically. Putative olfactory receptors have been identified (Buck and Axel, 1991; Buck, 1993; Ngai et al., 1993; Raming et al., 1993). The process by which scent is transferred to the brain is somewhat understood (Shepherd, 1994); however, the mechanisms by which receptors detect odorants, and thus the molecular basis of odor, remain unclear. As has been noted by Turin (1996), structure-odor relations provide conflicting evidence. It is known, however, that animals have the ability to differentiate targets based on scent, and recent scientific advancements have shown that odor recognition is a function of quantum mechanics and not molecular shape (Franco et al., 2011). Dogs can be trained to find specific classes of targets, and can even discriminate one person’s scent from all other human and non-human scent (Schoon, 1998), yet how they do this remains unexplained. Recent research by Franco et al. (2011) has shed some insight using fruit flies;

however, this work has yet to be validated in mammals. Therefore, it is not possible to explain precisely how dogs use scent to find desert tortoises, other reptiles (Schwartz et al., 1984; Engeman et al., 1998), or even to distinguish cancer in human subjects (McCulloch et al., 2006) However the results of past studies conducted to assess dog capabilities at finding desert tortoises document this capability (Cablk and Heaton, 2006; Cablk et al., 2008; Nussear et al., 2008).

DTK9s are trained to locate live tortoises and not deceased animals, tortoise remains, scat, urine, or residual tortoise odor persisting in the absence of a live tortoise. This is because the typical management need is to locate live animals and not sign. Scat, urine, residual tortoise odor, and tortoise remains can be fairly ubiquitous and long lasting in the desert environment and may persist long after a tortoise has moved location. Focusing effort to clear a burrow that contains scat and not a live tortoise can be environmentally destructive and counterproductive for the survey goals. Dogs could be trained to locate a broader target class to include scat and deceased animals; however, these teams would not necessarily be appropriate for all types of survey deployments, such as those where only live tortoises were the target.

The dogs in this program were initially trained as described in Cablk and Heaton (2006). For a dog to be able to locate a desert tortoise, it must first learn to recognize desert tortoise odor, which is a chemically undescribed odor signature. This is referred to as the dog's target odor. Teaching the dog target odor recognition is accomplished through behavioral patterning using reinforcement by presenting reward in association with desert tortoise odor. Typically dogs are rewarded with handler-focused play, such as tugging or very short distance retrieve of a toy, or with food. Once the dog has established its target odor it must learn to be able to communicate to its handler when it detects the presence of target odor. To accomplish this, the dogs are taught that to elicit their desired reward they must perform the trained behavior "sit" next to the tortoise or next to the burrow or shrub where a tortoise is located (Figure 7). This is quickly accomplished when the dog has high motivation for its reward and the trainer is skilled at the timing of reward delivery. Dogs are taught to not interact with tortoises using a variety of methods depending on the dog's response to the tortoise. They are trained not to alert (sit) at non-target odors primarily through reinforcing just the live tortoise odor. However, this may also be accomplished through either non-reinforcement or negative reinforcement of non-tortoise odor responses as appropriate or necessary.

Field operation of a dog trained to locate a live animal of a federally and state protected species of any kind requires a skilled handler. The handler is responsible for optimizing the dog's nose such that the dog has every opportunity possible to cross its minimum detection threshold of tortoise odor. This is accomplished by implementing a grid search strategy which requires the handler to be capable of multitasking, e.g., handling of the dog and leash, working a Global Positioning System (GPS) unit, maintaining straight grid lines of travel, reading the dog's behavior as it searches, and ensuring safety at all times. There are two instances when a properly trained dog may not perform its trained alert although a tortoise may be present: (i) the location of the tortoise presents an odor picture with concentrations lower than or at the threshold that the dog has been trained to and (ii) the particular tortoise odor is at the edge of the dog's generalized "'tortoise" signature. In either instance the dog approaches the threshold of what triggers it to identify the presence of a live tortoise and perform its trained alert. It is the responsibility of the handler to recognize that the behavior of the dog signaling a tortoise may be present in the

absence of the trained alert. The handler is also responsible for maintaining the health and welfare of the dog, recognizing when environmental conditions are outside the acceptable range for DTK9 deployment and ensuring that the dog is calibrated and motivated as it works. Because of the cryptic nature of desert tortoises in combination with being particularly vulnerable to being crushed when small, the handler must be highly aware of where he or she steps just as would any human surveyor. The challenge for the dog handler is the need to maintain situational awareness for both the human and dog components of the team during all active survey times.

Figure 7. A DTK9 performing its trained alert (sit) focuses on the handler who approaches to reward the dog in place.

The overall methodology for the final demonstration conducted in spring 2008 is shown in Figure 8. Initial scent training was conducted individually by each handler at their home location using a defined protocol with provided training aids. Upon completing this preliminary training, the teams traveled to Las Vegas for participation in the demonstration. This preparation included all final training components for dog and handler. Upon arrival at DTCC, each team was evaluated on training aids to determine whether or not the dog had been properly trained to recognize tortoise odor. The dogs were then desensitized to tortoises. Desensitization was done so the dogs would be accustomed to the sounds and movements of live tortoises, which were not associated with their target odor as trained at home. The dogs were then transitioned to live tortoises. Handlers were also trained to execute a prescribed search strategy, use a GPS, and were trained on safety measures. The handlers were then taught Read-and-Go as described in Section 3.3. Three assessments that together comprised the certification were then conducted. The three

assessments included safety, a high density scenario, and a low density scenario. All of this work was accomplished at DTCC from April 1-22, 2008. Dog teams were then fielded in Piute Valley April 23-29, 2008. Each day of the field trials tortoise availability was determined, which was necessary to conduct the calculation of metrics in support of performance objectives. Following the field testing at Piute Valley, data were complied and analyzed. Results from DTCC and Piute Valley were compared. Based on the results, standards and supporting documentation were written.

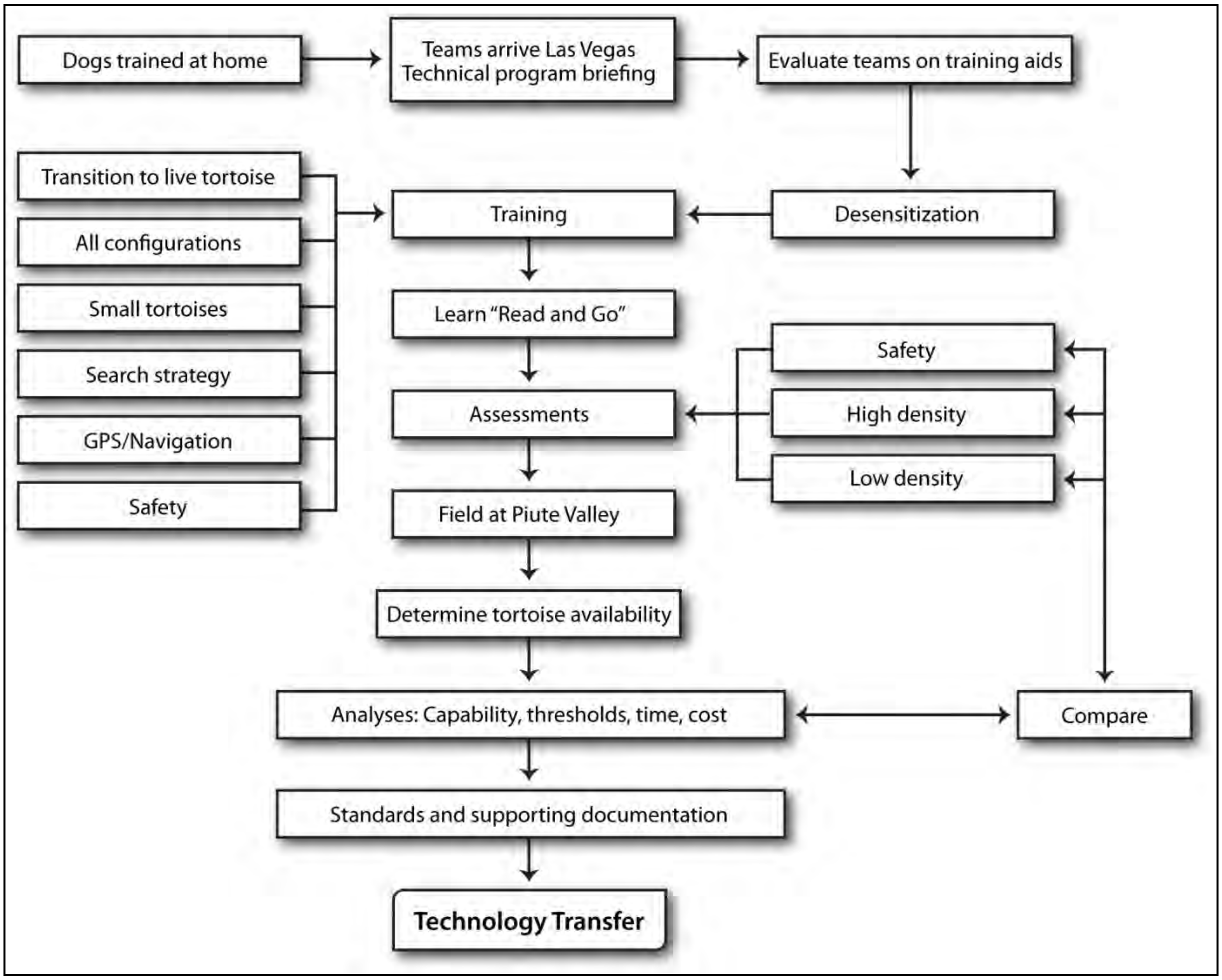

Figure 8. Flow chart depicting the approach employed in the final demonstration conducted in spring 2008.
The demonstration occurred at handlers' home locations, at DTCC and Piute Valley, NV.

Figure 9 diagrams the process for how the technology can be implemented. This approach has been developed with and continues to be under discussion with USFWS as the agency responsible for federal permitting and oversight of DTCC. Dog teams may or may not be trained by professional trainers using the DTCC facility during initial training stages before undergoing the testing process (developed and assessed from Phase I). Elective final preparation at DTCC prior to taking the certification test would be recommended but not required. The certification testing would be conducted using the DTCC facilities. Those teams that pass the tests would

receive documentation to submit to the permitting agencies (e.g., USFWS and appropriate state agency) with permit applications to conduct work involving desert tortoises using dogs. This is complementary to the process for permitting human surveyors as an individual's curriculum vitae (CV) is required documenting specific desert tortoise handling and related experience. Documentation of passing the certification test for desert tortoises is the equivalent to a dog's CV in that it shows that the team was able to meet a minimum level of proficiency and maintain safety while surveying. Teams that did not pass would be unable to provide documentation to permitting agencies and would require retraining before attempting the certification test again. We recommend that dog teams that are granted permits to work with desert tortoises be considered certified for one year and should pass the testing regime annually to maintain current status for permitting purposes.

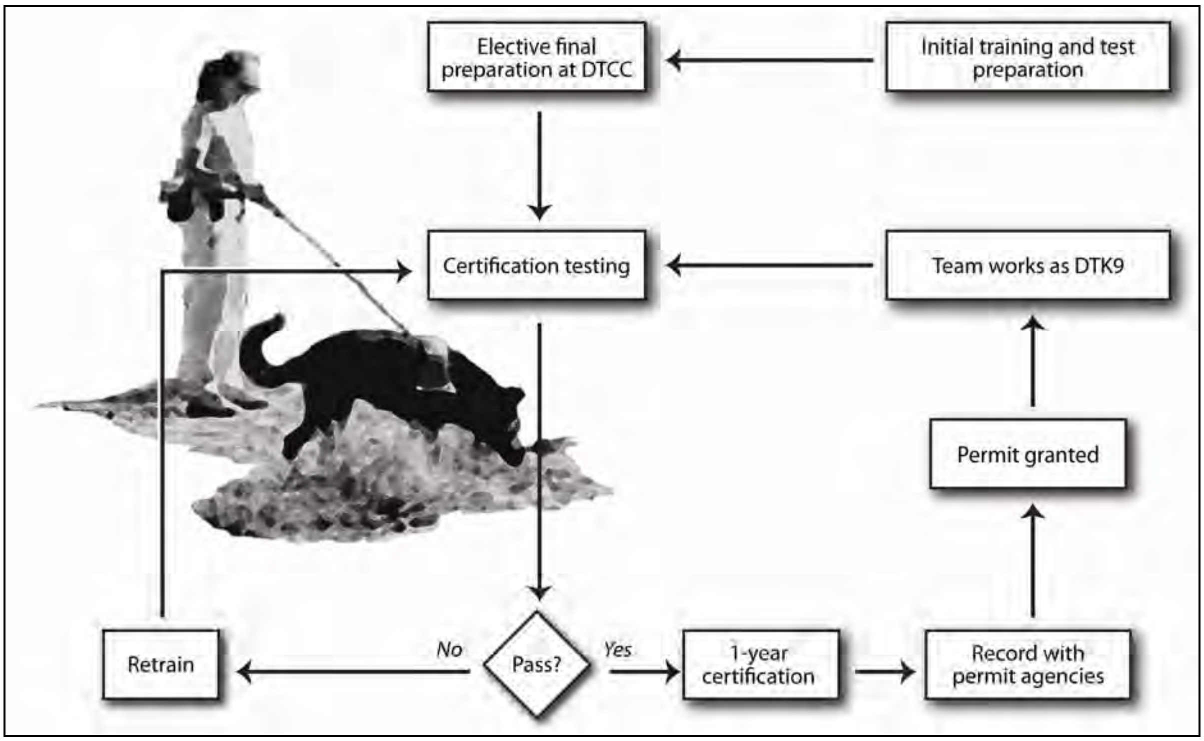

Figure 9. This flow chart shows the process for achieving status as a permitted DTK9 team, certified for consideration to be permitted, and thus deployed for work, by the permitting agencies.

The chronological development of the DTK9 technology began in 2002 with the initial idea of using dogs to find desert tortoises arising out of the need for an additional survey tool and is diagrammed in Figure 10. The first 2 years involved non-field efforts putting together a qualified team to conduct the initial pilot study and securing permits for the research. The pilot study pairing dogs and tortoises was conducted in April 2004, and the chronological sequence of research and development are summarized in Section 3.2 and Section 3.3. Details of the pilot study were published in Cablk and Heaton (2006).

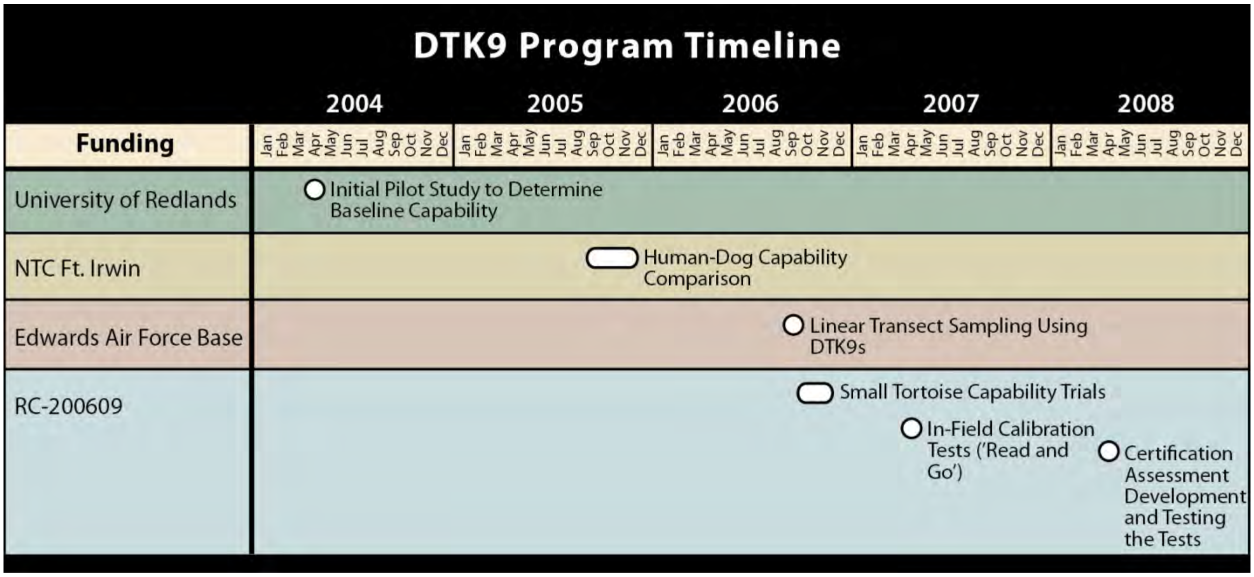

Figure 10. Chronological sequence of DTK9 development from 2004 to present.
The sponsor for each progression is shown by color.
Most of the research and development was sponsored by DoD.

Expected applications of DTK9 teams are limited to Mojave Desert tortoise, although it is possible that with some adjustment in training and in search strategy they could be deployed to search for Sonoran desert tortoises as well. Under the current training and testing regime, DTK9 teams would be appropriate for surveys where the objective is to locate live Mojave Desert tortoises. This might include clearance surveys, assistance with mark-recapture and telemetry studies, demographic surveys, and also to assist in locating hatchling and juvenile tortoises where nests recently hatched or in the vicinity of numerous females of reproductive age. DTK9 teams would be useful to locate tortoises for studies involving health assessments, genetic surveys, and identifying gravid females, among others. They may be fielded in conjunction with human survey teams or as a stand-alone approach, although handling of desert tortoises is expected to be outside of the responsibility of the handler. The degree to which DTK9s can readily transfer to other tortoise or turtle species is unstudied; however, it has been shown in other detection dog disciplines that once a dog learns one target odor, learning additional target odors is accelerated. It should not be assumed, however, that because a dog has certified to tortoise odor that it would be successful at locating other tortoise or turtle species without additional training.

3.2 DTK9 DEVELOPMENT 2004-2006

April 2004: Initial Pilot Study to Determine Baseline Capability

The pilot studies were conducted at DTCC to provide a proof-of-concept verification that dogs could be trained to find desert tortoises. The pilot study focused on safety and used quantitative metrics of efficacy and reliability to determine success. Professional wildlife-scat detection dogs were evaluated for participation in the project. Initially five canines were evaluated, two of which were subsequently selected for participation in the research (Figure 11). Safety concerns with three of the five canines resulted in their being excused from the program.

Figure 11. DTK9 Pilot project research team was initially conducted as proof of concept using two dogs.

Of interest was that the canines rejected for safety reasons were deemed certified DTK9s by the trainer/owner. The two canine teams that participated in the trials returned greater than 90% find rates of adult tortoises and could do so safely under the semi-natural conditions at DTCC. The canines found five very small tortoises less than 60 mm MCL, although these finds were not part of the designed research trials. Nonetheless, the finds provided the first evidence suggesting that canines might be capable of locating small desert tortoises. The results of this pilot research, published in Cablk and Heaton (2006), were positive and the next phase of development, a human-canine capability comparison, was funded by NTC Fort Irwin through the U.S. Army Research Office.

<u>September – November 2005: Human-Canine Capability Comparison</u>

Having completed the proof-of-concept, the next step in the DTK9 development was to compare the effectiveness of canine teams with that of human teams surveying for desert tortoises in the natural field setting. DTK9 training was conducted at DTCC, and the field comparison was conducted at the NTC Fort Irwin Southern Expansion Area. A call for handlers was released that targeted canine handlers with a background conducive for the work. Primarily, canines trained in search and rescue applied. DTK9 teams were trained at home using methods described in Cablk and Heaton (2005) and then brought to DTCC where they transitioned to live tortoises and subsequently completed a 12-day training and testing program. The training focused on adult and sub-adult tortoises. Limited training was provided on tortoises smaller than 110 mm MCL. Of the 10 DTK9s evaluated at DTCC, six were selected based on capability and safety. These six DTK9s were fielded at NTC Fort Irwin as the "dog" team against which they competed with the "human" team. The comparison used six canine teams versus 11 humans (Figure 12). Each team surveyed a total of 10 km^2 (the same geographical area) over five weeks, making two complete passes of the area (Figure 13). The data from dog and human surveys were compared. Canines and humans performed equally well at finding desert tortoises under the ambient conditions present at NTC Fort Irwin during that time period, with a probability of detection for either humans or canines approximately 0.70. Canines were found to have higher find rates for tortoises

in shrubs. They were also able to complete the equivalent-sized search areas to humans' search significantly faster, although this was not shown to be a true advantage over humans since the canines could not work additional areas in a day. The results of this work are published in Nussear et al. (2008).

Figure 12. The 2005 "human-dog comparison" fielded six DTK9 teams and a human survey team of 11 authorized tortoise biologists.

Figure 13. A DTK9 searches for tortoises during the human-dog comparison study, 2005.

September 2006: Linear Transect Sampling Using DTK9s

In 2006 DTK9 teams were used to collect data for a comparison with results from standard line-distance sampling efforts conducted by USFWS on EAFB, CA. Four DTK9 teams surveyed the same linear transects previously surveyed by line-distance sampling teams (humans) (Figure 14). The implementation of the activity in the field seemed to work well with the exception of individual navigation problems involving long distances over linear transects. However, the results were ambiguous and few tortoises were found (Cablk et al., 2007).

Figure 14. Four DTK9 teams were fielded on EAFB to compare results with LDS surveys from previous years and to assess effectiveness of DTK9s at transect surveys.

3.3 DEVELOPMENT OF DTK9 TEAMS UNDER ESTCP RC-200609

The work conducted under ESTCP RC-200609 encompasses 3 years of additional development and the final demonstration of the technology. The funded work included focus specifically on canine teams finding small tortoises using rigorous experimental approaches, field experiments with small tortoises in situ, advancements in training protocols and deployment, development of a certification test, administering and validating that test, and final demonstration of DTK9 capabilities to locate all size classes of tortoises in the natural environment and expected densities using quantitative and qualitative performance metrics. Significant changes in the deployment of canine teams were made during the course of RC-200609 based on advancements in understanding search strategy optimization for small target odor coupled with safety aspects, which in turn expanded the range of conditions under which canines can be fielded.

October – November 2006: Small Tortoise Capability Trials

All development of DTK9 teams up until 2006 had been primarily on adult or sub-adult desert tortoises. DTK9s had not been shown to be able to locate the smaller size classes of tortoises with any certainty. Training specifically on small tortoises had not been integral to the training program for a number of reasons, including availability of small tortoises for use in training at

DTCC, safety concerns, and time and cost constraints. Because the previous studies had provided mixed results on small tortoises, the first step was to undertake a rigorous approach to test DTK9 team capability for the smallest size classes.

To begin to address the remaining possible influential factors, a training program was designed specifically for small desert tortoises. The training program drew four of the six DTK9 teams from the previous field season at NTC Fort Irwin (Figure 15). These teams were already trained and accomplished at conducting field surveys for desert tortoises and presented a low safety risk. The training program focused entirely on the smallest size classes of tortoises. A total of 21 different tortoises between 52-84 mm MCL were used over the course of the training. Training began with basic odor recognition exercises with canines worked on leash and tortoises placed in small protective cages approved for use by the USFWS. Initially, the alert was cued by the handler. The next progression followed standard detection dog training methods involving scent box lineups (e.g., Mistafa, 1998). These exercises were conducted until the canines were able to correctly and independently alert (sit). The training next progressed to presenting tortoises to the canines directly, without barriers. Once the canines were actively searching for, safely locating, and performing independent alerts on small tortoises, the experimental trials began.

Figure 15. The 2006 FISS trials included four DTK9 teams selected from the previous field season's effort and focused only on small tortoises.

The four objectives for these experimental trials were to quantify: (i) efficacy, (ii) reliability, (iii) within-canine variability, and (iv) among-canine variability of DTK9 teams at finding small desert tortoises under seminatural conditions in a controlled environment. Efficacy and reliability are not necessarily related but together show the capability of a DTK9 team. Variability within and among DTK9 teams distinguishes the performance levels of individual canines, and quantifies the consistency of canines as a survey resource. At DTCC, two 100×100 m pens were identified for testing and then cleared of tortoises for use in the trials and divided into four

50×50 m quarters. Two different size search areas were used, 50×50 m (0.25 ha) and 100×100 m (0.5 ha).

A total of 20 trials were conducted between October 29 and November 12, 2006. Forty-three tortoises were placed in two configurations on the landscape, either in a burrow or under a shrub. The tortoises used in the trials ranged in size from 54 - 81 mm MCL and had been withheld from training exercises, thus were not previously encountered by the canines. Placements were sited at spatially random points in the DTCC test plots.

Overall, the DTK9s were 98% accurate for finds and misses. They were 94% accurate on the basis of finds, misses, and nonproductive alerts. Overall, the DTK9 teams were 85% reliable. They located 98% of the small desert tortoises placed at the base of shrubs and 97% of the desert tortoises placed in burrows. There was no significant difference in efficacy across the DTK9s for the 0.25 ha trials, (X^2=2.68, n=56, p=0.44), but a significant difference in efficacy was observed for the 0.5 ha trials (X^2=9.35, n=24, p=0.03). It should be noted that the mean range of efficacy for 0.5 ha trials for the four canines was 93% to 99%. Although the test had sufficient power to determine a statistically significant difference in performance between a 93% canine and a 99% one, all canines performed exceptionally well from a practical perspective and would not be considered unsuitable for fielding as a result of being "only" 93% accurate.

DTK9s returned variability in their consistency in performing trained alerts, although reliability overall ranged from approximately 0.92-0.956. DTK9 teams were able to cover 0.25 ha in approximately 30 minutes and, as would be expected, covered 0.5 ha in just over an hour on average. Total working time did not differ across trials (0.25 ha: $F(13,42)=1.31$, $p=0.243$; 0.5 ha: $F(1,6)=0.07$, $p=0.802$). For 0.5 ha plots, there was no difference in time to complete surveys between DTK9 teams ($F(3,4)=0.91$, $p=0.513$); however, for the 0.25 ha plots one DTK9 team differed significantly from each of two other teams ($F[3, 52]=6.96$, $p<0.001$).

The four DTK9 teams were then fielded at the NTC Fort Irwin Study Site (FISS) from November 15 to 19, 2006 to determine their capability in locating small radio frequency transmitter-bearing desert tortoises under natural field conditions and tortoise densities. The tortoises used in this deployment were part of an ongoing Head Start research project and had been living in the natural environment with transmitters for most of their lives (Figure 16). FISS is the only location on military land in the Mojave where small tortoises with transmitters and known locations were available for use.

Figure 16. A small tortoise burrow at FISS. Verification of a tortoise in the burrow was conducted via telemetry.

The dogs performed collectively at a maximum of 50% effectiveness, which was much lower than the results from the DTCC trials recorded immediately prior to fielding at FISS. On the first day at FISS the DTK9 teams found no tortoises. Additional training was conducted on Day 2 and resulted in an improvement of performance on Day 3. Without training between Day 3 and Day 4, performance decreased. Given the success demonstrated at DTCC, these results were unexpected. A number of possibilities were identified as potential confounding factors that might have affected the teams' performance, including environmental conditions, time of year, and physiology of the tortoises. Two factors were identified as having a high degree of impact on the

FISS field trial results that could also be mitigated through a different preparation schedule prior to fielding: (i) minimize extraneous odors in the dog's recognition of the odor signature "tortoise" and (ii) maintain team calibration in a search environment where targets are unverifiable and occur in very low densities. Other possible factors such as weather, tortoise physiology, or airflow dynamics of burrows were deemed uncontrollable from training and testing perspectives. A follow-on study was designed and an additional field season, focused on DTK9 training (including minimization of tortoise handling), was scheduled at DTCC for April 2007 to address the issues raised by the FISS test.

April 2007: In-Field Calibration Tests (Read-and- Go)

Two of the four teams from the fall 2006 FISS study returned to DTCC in April 2007 and participated in a modified training protocol (Figure 17). This new training protocol was developed to address the potential issues identified in the previous field season at FISS in November 2006. In the 2006 experiments at DTCC, the tortoises were handled heavily and maintained in small cages to enable a rigorous experimental design with repeated measures while simultaneously protecting the tortoises. While this provided for good statistical power, it affected the research because it resulted in the dogs being tested on an expanded odor signature rather than solely on small desert tortoise target odor.

Figure 17. Two veteran DTK9 teams participated in the development and testing of the in-field calibration method, Read-and-Go.

Another factor that affected the results from fall 2006 was that transitional training was not conducted for the dogs or their handlers between the DTCC and FISS deployments. For the dogs the transitional training would have been to minimize if not eliminate the background non-tortoise odors and to reinforce live tortoise odor. For handlers the transitional training would

have included preparation for a drop in find rate, which had already been documented in previous work.

Under natural conditions DTK9 teams can work for days without finding any tortoises. When the dog performs its trained alert at a burrow, the handler does not have an opportunity to investigate the burrow and therefore the dog will not be given its reward. Correct behavior by the dog extinguishes in the absence of reinforcement. In addition to the practical aspects of operant conditioning on the dog, there is a human element that plays a significant role in the dog's performance. Lit et al. (2011) showed that handlers have the ability to bias their dog's performance simply by having a belief about targets in their search area. In the case of tortoise surveys, what was particularly difficult for the handler was not being able to reward his or her dog when the dog had performed correctly and secondly they succumbed to doubtful or negative thought patterns about their dog's abilities as time passed and their dog made no finds or did not perform its trained alert. This occurred without the handler having knowledge of presence or absence of tortoises. Managing the handler mindset became a requirement for maintaining an operational team. These problems were resolved with the development of an in-field calibration process using a variable-intensity reward system designed for low target density with unconfirmed alerts. This process was termed Read-and-Go because the overarching objective as explained to handlers was that they read their dog's behavior, make their determination of target or no target, and continue on with their search strategy. Read-and-Go is the foundation of an operational DTK9 team.

The development and testing of Read-and-Go was conducted from April 18 - May 3, 2007. The overall objective of this field season was to assess and refine training protocols developed for small desert tortoises. The specific objective was to evaluate degradation in alert behavior in the dogs over time when given varying levels of reward for finding tortoises. The initial training included a systematic progression of assessing the dog alert process and safety around tortoises to fielding of dog teams at DTCC with primary emphasis on small tortoises <100 mm MCL. The dog teams were continuously evaluated over the course of the training period for safety and performance. Dogs were allowed to interact with tortoises at DTCC under controlled conditions that progressed from dogs sitting next to caged tortoises to dogs searching for and then sitting next to free ranging tortoises on the surface, under shrubs, and in burrows. All dog activities were performed on leash. This was the origin point for all DTK9 teams work on leash and was established for safety and search strategy reasons.

Eighteen small tortoises were transmittered and released into outdoor pens at DTCC on April 12, 2007, prior to the dog teams' arrival (Figure 18). This enabled human odor associated with the transmittering and handling of the tortoises to dissipate and allowed the tortoises to locate within pens naturally. The dogs were trained on small to large tortoises with minimal handling. An additional 18 hatchling/juvenile tortoises without transmitters were used in the training assessment activities.

Figure 18. Small tortoises were transmittered and released into select pens before DTK9 teams arrived on site.

Handlers worked two different search areas each day as an operational team using Read-and-Go. In the first area the number and size classes of tortoises was unknown. The second area contained transmittered small tortoises that were verified after the handlers completed their search and left the area. Tortoises were verified using telemetry which enabled them to remain unhandled and established in their self-selected location. Handlers were never provided with their response rates.

The results showed that the dogs' alert behaviors did not diminish over time with the variable intensity reward system Read-and-Go. Neither dog had a significant change in proportion of independent alerts to non-alerts at tortoises over the course of the 5 days of testing (Dog 1 X =5, DF=3, p=0.172; Dog 2 X^2=11.25, DF=9, p=0.26). These results suggested that the use of Read-and-Go maintained the dogs' alerts and is a means to maintain team calibration in-field. Over the 5 days of trials, the dogs readily located small desert tortoises in relatively uncomplicated presentations under bushes and in burrow entrances, but more importantly they also found the small tortoises deep in diminutive mammal burrow complexes, not readily visible and where digging was required to extract the tortoise. Results showed no significant difference between the dogs in proportion of independent alerts (n=10, F[4,4]=4.23, p=0.192) nor a difference in the change in behavior correctly interpreted by the handler (n=10, F[4,4]=4.95, p=0.151).

3.4 ADVANTAGES AND LIMITATIONS OF DTK9 TEAMS

As with any tool or method, there are advantages and limitations to using dog teams to find desert tortoises, particularly in the harsh desert environment. Based on the results from RC-200609, DTK9 teams could provide means to gather demographic data to meet regulatory and stewardship needs when trained and deployed properly. A cost-effective and efficient means of documenting the full desert tortoise population, not just the adult segment, offers the possibility of better understanding the reasons for the declining numbers of desert tortoise across the Mojave Desert. This is a specific technical advantage of DTK9s.

DTK9s have been shown to be better than humans at finding tortoises in shrubs (Nussear et al., 2008), which has particular relevance since tortoises spend up to 20% of their time in shrub

cover (second only to time spent subsurface). An assessment of human capability comparable to RC-200609 remains outstanding, making it difficult to directly compare DTK9 teams versus humans over the full range of desert tortoise size classes. Statistics on human find rates for tortoises ≥180 mm MCL are reported in USFWS range-wide monitoring reports. Humans have variable find rates for desert tortoises ≥180 mm MCL, depending on level of training (USFWS, 2010a). DTK9 team find rates also exhibit variability; however, the measurement range is over an expanded range of size classes.

While the use of DTK9 teams presents an opportunity to gather data on the missing desert tortoise demographic, there are limitations to be considered. Along with demonstrating that the DTK9 teams can find small tortoises, results from RC-200609 have also determined deployment parameters, including realistic area coverage estimates to detect the smallest size classes of tortoises. Conducting surveys for small size classes of tortoises over expansive areas would require tens or hundreds of DTK9 teams due to the necessary methodical search strategy required to conduct searches at that level of effort. The cost of conducting such detailed survey efforts at a broad scale would be considerable. Finding the smallest tortoises requires more detailed searching, which means that less area can be covered in a given day. Larger areas will thus require either more time to be covered thoroughly and/or additional DTK9 teams. Both of these options will increase costs. Surveying for the larger size classes of tortoises with DTK9 teams is expedient. Dogs can cover the same geographic area as humans in less time when searching for larger size classes of tortoises; however, they have not been shown to be able to cover more area per day than humans. Dogs can work into higher air temperatures when on leash than when off leash because their speed and subsequent energy expenditure can be controlled. However, it is unknown if working on leash to survey for larger tortoises would expand or reduce the area that could be covered or the length of time worked because this was not specifically tested after 2005. Surface temperatures can be a limiting factor for a dog, even with foot protection.

Although detection rates of adult tortoises by either dogs or humans have not been found to differ with environmental conditions (Nussear et al., 2008), the permitted cutoff temperature for handling tortoises as set by USFWS is 30°C (95°F). Humans work within this temperature by USFWS regulation regardless of cloud cover. By contrast, because of their limited cooling capabilities, dogs can work effectively only into the mid ~27°C (80°F) range in full sunlight. While dogs may work at higher temperatures in the absence of direct solar radiation (i.e., cloudy days), such conditions are not common in the typical Mojave Desert climate. For these reasons the length of survey season during warm months is more limited for DTK9 teams than for humans. Humans wear foot protection which significantly buffers their feet from surface temperatures that can be up to 30°F hotter than air temperatures. While booties protect a dog's foot from sharp vegetation a dog's foot is one of two places where active heat dissipation occurs through sweating. Wearing footwear limits the dog's ability to dissipate body heat and dramatically increases the dog's temperature, which limits the ability to effectively work. Because dogs are physically closer to the ground, which tends to be hotter, they tend to experience warmer air temperatures than humans do.

At the other temperature extreme, conducting winter surveys of burrows is possible (although this was not tested as part of RC-200609) and also surveying for small tortoises that may surface on anomalous and occasional "warm" winter days. It should be noted that extracting or disturbing tortoises in burrows in winter would not be permissible so surveying with DTK9

teams during cold months would have limited scope and application. This brings to light another challenge for which there is no resolution yet. That challenge is validating dog alerts for un-transmittered and small tortoises, which cannot be verified using visual means.

No tool is perfect and for this reason not all dog alerts will necessarily be correct or precise. The only means at present to validate a dog's alert on a burrow is either visual confirmation by a human or excavating. The latter is problematic because excavating a burrow is destructive. In the case of small mammal burrow complexes, it is destructive not only to the tortoise and a tortoise burrow, but also destructive for a greater complement of biota, including the shrub itself. The challenge with using a human, whether or not proficient with tools (i.e., scope, probe, etc.) to validate a dog alert, is that the return rate for humans on small tortoises has not been determined. Because the efficacy rate has been calculated for certified DTK9 teams, it may be possible to employ statistical correction to data when validation cannot be determined through excavation. It may be desirable to use another DTK9 team to validate alerts, where X of Y alerts from N different teams is required to deem a tortoise present. How unconfirmed alerts are to be handled in data collection should be determined prior to fielding teams.

Maintaining calibration of teams requires the handler to ensure both him/herself and dog function as an operational team. In the absence of any surface or known tortoises over the course of an extended survey period, the dogs will require calibration on live tortoises that can be transported to the teams in their survey areas. It is not expected that Read-and-Go can maintain a team's calibration for five or more days of surveying with no reward for the dog. Building in the possibility to have calibration tortoises available and a means to deploy them effectively during surveys is a permitting consideration.

A natural extension of dogs to locate Mojave Desert tortoise is the potential to use dogs to find tortoises in other habitats. The Sonoran population of desert tortoise is protected at the state level in Arizona but is not federally protected south and east of the Colorado River. While its habitat is described to have very different characteristics from the Mojave populations, it may be possible with adjustment of training, testing, and deployment guidance to use dogs for tortoises outside the Mojave Desert.

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4.0 PERFORMANCE OBJECTIVES

Performance objectives are the primary criteria established to evaluate the utility of DTK9s and provide the basis for evaluating performance and cost. Meeting these performance objectives was essential for successful demonstration and validation of DTK9 utility. In this section we describe the performance objectives (Table 1). All objectives were met and are discussed in full in Section 7.0.

Both quantitative and qualitative performance objectives were established that related directly to safety and capability. A dog team, either dog or handler or both, that poses a safety threat does not meet the criteria to be a DTK9 team. Capability is the combination of efficacy and reliability where *efficacy* is the number of tortoises found of the number available to be found and *reliability* is the number of times a dog performs its trained alert, sit, upon first encounter with a tortoise. The DTK9 team should have high efficacy and high reliability. A team with high efficacy and low reliability needs retraining to meet the qualifications. A team with low efficacy and high reliability may need retraining or may not meet the criteria for a DTK9 team. A team with low efficacy and low reliability does not meet the criteria for a DTK9 team.

4.1 CERTIFICATION TESTS YIELD TEAMS THAT PERFORM TO STANDARD

This performance objective was designed to determine the suitability of the certification test that included three phases of assessment, described in Section 6.2, to produce DTK9 teams that could conduct field surveys to a known detection rate. The purpose of this objective was to validate the design of the certification testing recommended for permitting DTK9 teams in the future. Furthermore this objective demonstrated that DTK9 teams could perform to a known standard.

The success criterion for this objective was a threshold value for each of efficacy and reliability. Success was indicated when a team met the success criteria for both the certification AND the demonstration or when a team failed the success criteria for both the certification AND the demonstration. If a team was able to meet the certification criteria but not meet the criteria during the demonstration, the result of the objective was considered not met. Likewise, if a team that did not meet the certification criteria went on to meet the demonstration criteria in the field at Piute Valley, then that too would have been an unsuccessful result. The latter two results did not occur. Teams both met the criteria during certification assessment AND went on to meet them during the field demonstration, or they did not meet the certification criteria AND also failed to meet them during the field deployment.

4.2 DOG TEAMS FIND TORTOISES OF ALL SIZE CLASSES

The purpose of this performance objective was to demonstrate that the DTK9 teams that passed the certification criteria would detect the full complement of size classes that occur in nature. This was assessed using efficacy and reliability calculated by size class for each phase and directly compared.

Success criteria for efficacy were threshold values by size class. Reliability threshold was constant across size classes. The threshold criteria are provided in Table 1. The success criteria were exceeded for all size classes.

Table 1. Performance objectives established to validate DTK9 teams.

Performance Objective	Metric	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives				
Certification tests yield teams that perform to standard	• Team capability in the field reflects performance on assessment tests	• Assessment data • Field data for efficacy and reliability	• Efficacy for tortoises≥70% • Reliability≥75%	• "Passed" teams met success criteria (Efficacy and reliability both=90%) • "Failed" teams did not meet success criteria (Efficacy=50%; Reliability=44%)
Dog teams find tortoises of all size classes	• Efficacy • Reliability	• Test plots with transmittered tortoises of all size classes • Tortoise locations verified to validate alerts • Data recorded on dog alert behavior	• Efficacy for small tortoises≥50% • Efficacy for medium tortoises≥60% • Efficacy for large tortoises≥70% • Reliability≥75%	• Efficacy for small tortoises=0.78 • Efficacy for medium tortoises=0.96 • Efficacy for large tortoises=100% • Reliability across all size classes=90%
DTK9s can operate in Read-and-Go reward strategy	• Reliability • Handlers administer variable reward as defined by Read-and-Go	• Reliability calculations • Three levels of reward recorded in the field	• Dog team maintains≥75% reliability throughout the survey • Dog team is effective • Handler administers three levels of reward in the field	• "Passed" teams: Reliability across all size classes=90% • "Failed" teams: Reliability across all size classes=55% • Efficacy reported as above • Read-and-Go administered
Qualitative Performance Objectives				
Safety	• No permit violations that cannot be mitigated	• Tortoises of all size classes • Dogs have full access to tortoises without physical protection	• Project continues to completion	• No permit violations that could not be mitigated
DTK9 teams fielded under natural environmental conditions and employ search strategy	• DTK9 teams complete surveys of their assigned areas in one day	• Completed data sheets • GPS track data	• GPS track shows at least one complete pass through the search area • Field survey is completed with a database to analyze project data	• GPS tracks indicated at least one pass was completed for each surveyed area • A final database was complete and used to analyze project data

4.3 DTK9S CAN OPERATE IN READ-AND-GO REWARD STRATEGY

The ability to remain an operational team over potentially long time periods without finds and/or reward for finding tortoises underlies the usefulness of a DTK9 team. The dog must continue to find and alert on live tortoises in the absence of reward. The handler must continue to maintain a positive mindset without imparting bias to the dog (Lit et al., 2011). This objective was assessed during the field demonstration at Piute Valley.

Two metrics were established to assess this performance objective—reliability and the handler administered Read-and-Go. Success criteria included the same reliability threshold as for the other two quantitative performance objectives—the dog being effective as established in Section 4.2 and the handlers administering Read-and-Go. The success criteria were met.

4.4 SAFETY

Safety is a paramount requirement for a listed species and was continually assessed throughout the course of this demonstration. The permitting agencies establish the types and number of "take" incidents allowed during the course of work conducted under a specific permit. Because take has a fairly broad definition, permit violations may sometimes be mitigated. An example might be taken from a vehicle, with mitigation action being reduced speed limit and people walking ahead of vehicles to sweep for tortoises.

The metric to assess safety to tortoises was that there were no permit violations that could not be mitigated. Success was determined by the project continuing to completion. There were no permit violations that could not be mitigated over the entire course of this demonstration. This success criterion was met.

4.5 DTK9 TEAMS FIELDED UNDER NATURAL ENVIRONMENTAL CONDITIONS AND EMPLOY SEARCH STRATEGY

To document DTK9 utility as a stand-alone technology, it was necessary to conduct the final demonstration under the expected deployment conditions. A DTK9 team should be able to complete the assigned survey area each day while meeting the other performance metrics. A number of factors may affect a DTK9 team's ability to complete their survey area, including but not limited to surface and air temperature, fitness of the handler and dog, physical health of the dog (or handler), and accumulated fatigue over time. To be effective at detecting tortoises within an area, the team must at least survey within that area. The results of the survey in the form of data are also important.

The metric evaluated was whether or not teams completed their assigned survey areas each day. The success criterion was a GPS track that showed at least one complete pass through the search area and the data recorded for each team over the surveys resulted in a database. These criteria were met.

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5.0 SITE DESCRIPTION

5.1 SITE LOCATION AND HISTORY

Two sites were selected for the demonstration conducted in southern Nevada and are shown in Figure 19. DTCC is located southwest of Las Vegas on BLM land in Clark County, NV, and managed by Clark County, BLM, and USFWS. All training and testing involving the interface of tortoises and dogs prior to fielding teams in Piute Valley occurred at DTCC. The Piute Valley field demonstration site is in the Nevada Mojave Desert in desert tortoise critical habitat and managed by the U.S. Geological Survey (USGS).

Figure 19. Demonstration sites in southern Nevada are shown with green dots.

5.2 SITE CHARACTERISTICS

DTCC has a mandate to support desert tortoise research and was created as a mitigation action for development in the Las Vegas valley after the desert tortoise (Mojave population) was federally listed as a threatened species. DTCC contains desert tortoises considered to have been “taken” and are therefore eligible for research designed to promote the conservation of wild populations. This site was selected because it is unique in being the only facility where a full demographic profile, from hatchling tortoises to adults, is maintained and readily accessible.

Piute Valley is an area of desert tortoise critical habitat largely composed of Mojave Desert scrub, with areas of mixed Mojave Desert scrub typical of mid-elevation sites in the Mojave (Figure 20). There are no facilities at this site and it is an unfenced open landscape. The Piute Valley study site is home to a population of animals at the Piute-Eldorado Desert Wildlife Management Area (DWMA). This population consists of 20 desert tortoises, a subset of which were used in this demonstration, that have been monitored as a part of the USFWS LDS program since the year 2000. The area was suitable for the final demonstration because a situation was required where we had access to transmittered desert tortoises so that finds could be confirmed when a DTK9 alert occurred. We were able to augment the area with small transmittered tortoises to create a known population to reflect the expected demographic distribution of a natural tortoise population. Access to transmittered small tortoises and transmittered adult tortoises is not available elsewhere across the species’ distribution.

Figure 20. The Piute Valley field site is mixed Mojave Desert scrub and is desert tortoise critical habitat.

6.0 TEST DESIGN

6.1 CONCEPTUAL TEST DESIGN

The test design was conceptually straightforward: train DTK9 teams, evaluate the teams based on quantitative and qualitative performance metrics (a certification standard), and compare the capability of teams in the natural deployment environment to determine the robustness of the certification test and the actual field performance of qualified DTK9 teams. The certification standard was developed based on field results from prior years of DTK9 testing but was unique in the validation approach to determine whether or not the certification standard would in fact yield qualified, capable teams, neither holding back qualified teams that should have been fielded nor allowing unqualified teams to be certified and fielded when they should not be (Cablk and Harmon, 2011). Table 2 presents the data on each of the seven DTK9 teams that participated in the demonstration, shown in Figure 21.

Table 2. DTK9 team data.

Team is a unique identifier. F = female and M = male. DTK9 veteran indicates the dog had prior deployment as DTK9. Origin is the handler's home location where initial scent training was conducted.

Team	Dog Breed	Handler	Dog	DTK9 veteran	Dog age (yrs)	Origin
7	GSD	F	F	Y	7	NV
11	GSD	F	F	Y	10	MT
12	Lab mix	F	F	Y	4	MT
13	Australian shepherd	F	M	N	5	OH
14	GSD	M	M	N	2	TX
15	Hound mix	F	M	N	1	MD
16	Labrador	F	M	N	2	WI

GSD – German shepherd dog

Figure 21. The research team for RC-200609 included seven DTK9 teams in addition to the research team, training team, and authorized desert tortoise biologists.

There were several operational training periods that supported the performance objective evaluations. Not all operational periods resulted in tangible results; however, the entire progression was critical to support evaluation of the performance objectives. The performance objectives were specifically focused on assessing DTK9 capability and the appropriateness of the assessment tests used to make capability determinations. The conceptual test design is shown in Figure 22, which is based on the demonstration design flow chart shown in Figure 8. The different operational training periods are color-coded to represent the different phases used to evaluate the technology.

The green box in Figure 22 represents the 4-week training period prior to participation on site at DTCC where handlers trained the dogs on residual odor and accustomed the dogs to working on a leash. When this initial training period was complete, the teams traveled to DTCC in Las Vegas where they were evaluated for odor recognition and alert process.

Phase I is shown in both dark and light blue colored boxes. This phase was considered baseline characterization and preparation and is fully described in Section 6.2. Phase I began when teams arrived at DTCC and the dogs were desensitized to live tortoises as part of the transition from residual tortoise scent to live tortoises, shown in box labeled “desensitization.” The “training” box includes all aspects of dog and handler skills as indicated in the left boxes, which point to training. When dog and handler were skilled at searching for and indicating live tortoises on the surface, in shrubs and in burrows, teams were taught the in-field calibration technique, Read-and-Go (Cablk et al., 2007). Teams were tested using the three assessments that collectively comprised the certification standard. Performance objective metric data were collected and analyzed to determine which teams scored sufficiently to pass and which teams failed. Once the assessments were complete, the demonstration moved to Phase II, evaluating the test and demonstrating full field capability of DTK9 teams. The DTK9 handlers were not informed about whether or not they received a pass or fail of the certification test in Phase I so as to reduce human bias in performance during Phase II.

During Phase II (tan boxes) data on each individual team’s performance at Piute Valley were collected, analyzed, and compared with their performance during the assessments in Phase I at DTCC. This approach then enabled quantitative and qualitative assessment of the teams using performance criteria presented in Section 4.0.

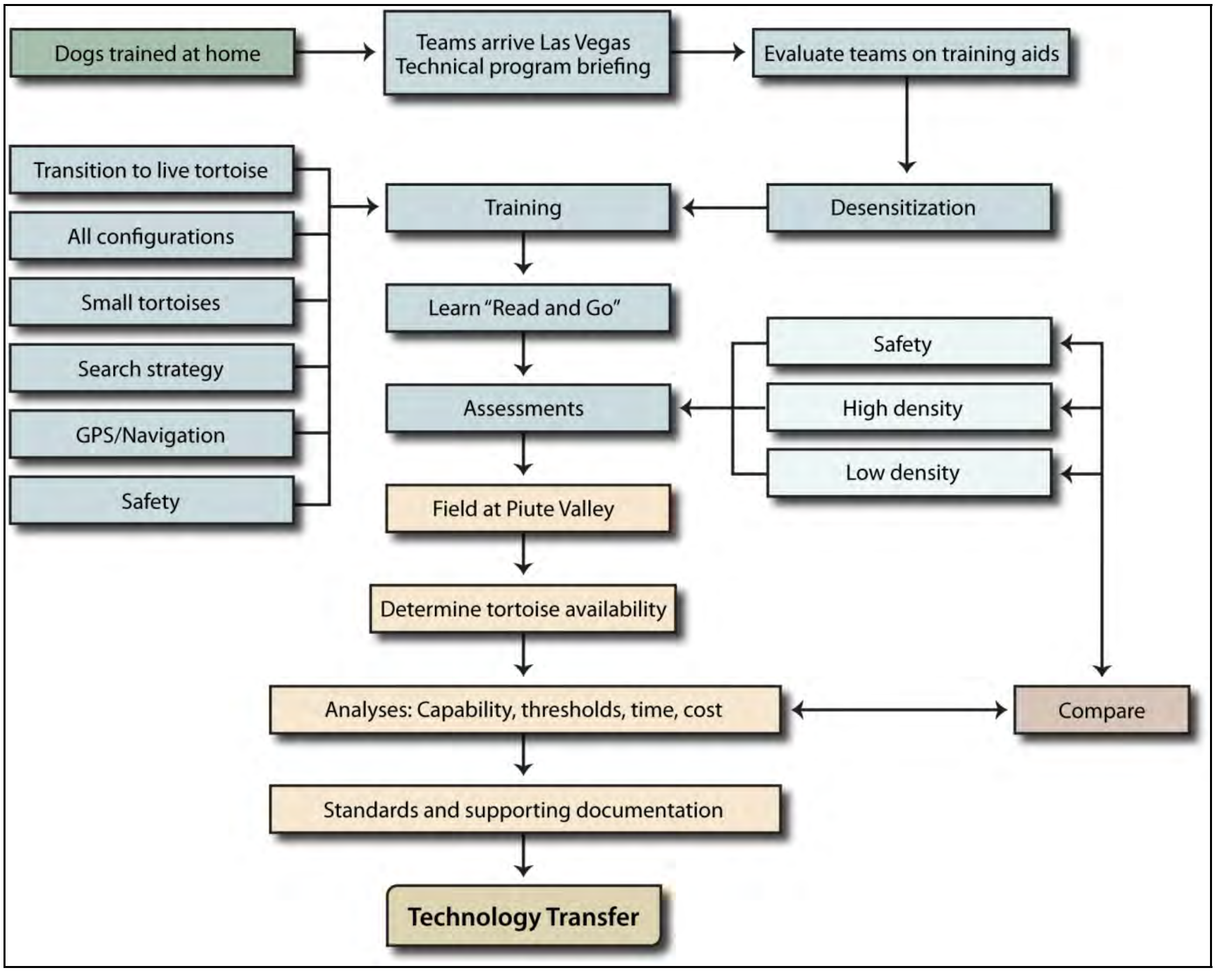

Figure 22. The conceptual test design.

For all aspects of the demonstration, safety was the highest priority used to evaluate the DTK9 teams. Any team that caused a permit violation that could not be mitigated at any time during the demonstration would have been deemed "failed" but also would have been removed from the program. This situation did not occur during the demonstration but was a critical evaluation component.

6.2 BASELINE CHARACTERIZATION AND PREPARATION

Baseline characterization was constructed from the point at which teams were evaluated for having accomplished basic scent recognition training through the final certification testing. The baseline was established for each of three different criteria: (i) safety, (ii) capability under high tortoise density conditions, and (iii) capability under low tortoise density conditions. The results of the baseline characterizations aggregated teams into one of two groups, those that passed all assessments and those that failed. A team had to pass all three assessments to be considered part of the passed group. Comparing the results from Piute Valley to this baseline was the means to evaluate whether or not the certification tests as designed yielded teams that performed similarly under realistic field survey deployments.

The safety and high density assessments were conducted at DTCC. The low density assessment was conducted in an area of BLM property adjacent to the Southern Nevada Water Treatment Facility in Henderson, NV. This area had been recently cleared of tortoises as they were frequently killed on nearby roads.

Baseline 1 - Safety Assessment

Although safety was evaluated throughout the entire demonstration, an initial safety assessment of dogs in the presence of live tortoises was needed to mimic implementation of future test conditions. Small pens approximately 15 m$\times$15 m and housing two–three adult tortoises were used for the safety assessment. Locations of the tortoises were verified by field personnel prior to a team entering the pen. The handler was made aware of all tortoise locations as well. The dog wore its working equipment, which included a flat collar, booties, a 6-foot leash and a remote training collar. The evaluator verified that the equipment was properly seated on the dog and working before the handler stepped into the pen. The dog's equipment was designed to provide safety assurances. The assessment began when the handler and dog were inside the pen. The dog was not given any commands nor allowed to move beyond the extent of the leash. The dog was observed for a total of 10 minutes while the tortoises free-roamed within the constraints of the exercise. The tortoises in the pen were unrestrained and field personnel were responsible for ensuring that the tortoises did not approach within 10 feet of the dog. After 10 minutes at the evaluator's direction, the dog team exited the pen and the exercise was scored. Safety was evaluated using the following nine distinct behaviors. Aggression is defined as an attempt to cause intentional harm to a tortoise.

1. Defensive aggression – Dog shows reduced body posture.
2. Overt aggression – Dog shows confident body posture.
3. Excessive Flight – Dog shows reduced body posture and repeatedly attempts to move away from the target.
4. Play interaction – Dog attempts to engage the target in play activity.
5. Growling – Dog vocalizes with a low rumbling sound at any time for any purpose or target during the test time period.
6. Barking – Dog vocalizes with a range of sounds, including whining, at any time for any purpose or target during the test time period.
7. Stalking – Dog shows low confident body posture while attempting to hunt or herd the target.
8. Excessive Focus – Dog does not easily look away from the target.
9. Inability to Relax – Dog cannot assume relaxed body posture.

Each behavior was scored from 1-5 so that a minimum (optimal) score is 9. A score of greater than 15 is considered a fail, and if any single behavior is scored 5, the team automatically fails. The following would result in a score of 5 and automatic failure: rushing a tortoise; attempting excessive flight greater than 15 seconds; play interaction attempted more than once; excessive focus more than 2 minutes; and inability to relax for more than 9 of the 10 allotted minutes. In

addition, if the dog growled at, barked at, or stalked a tortoise at any time during any of the assessments, the team would automatically fail.

Results for each team are shown in Table 3. DTK9 team 12 was not evaluated using this formal test because the team was not able to participate on the dates this test was administered. This team continued participation because handler and dog had worked in this program successfully for several years prior. Any team that did not pass this first assessment would have been excluded from further participation in the demonstration for safety concerns. Safety threat was the No-Go criterion for any team. No team tested failed this element.

Table 3. Results of the safety assessment for each DTK9 team.
The range of passing scores is 9-15.

Dog	Score
7	9
11	9
12	-
13	10
14	9
15	11
16	12

Baseline 2 – High Density Search Environment

Baseline characterizations conducted also included the high and low density assessments, which tested the teams in the two extreme densities possible during desert tortoise surveys. The high density assessment was designed to assess the team's ability to work in a situation where many tortoises would be present in a relatively small area, such as a recently hatched nest. In the high density assessment, 13 transmittered tortoises were released in a pen approximately 0.25 ha in size that contained natural burrows and shrub cover typical of desert tortoise habitat. The pen was not used for training activities prior to the assessment and was novel to the dogs. The counts of tortoises per size class released and available to be found were as follows: Small (≤110 mm MCL) – 5; Medium (110-180 mm MCL) – 6; Large (>180 mm MCL) – 2.

Dog teams were required to search the pen employing the standard three-pass search strategy involving a perimeter search followed by two cross-grid passes, which were termed the detail and hasty, respectively (Figure 23). The handler determined the entry point into the pen and verified visually that no tortoise was present at the point of entry. There was a 60-minute time limit to complete the three passes, and the assessment began when the team entered the pen. The dogs worked on a 10 ft long line. Teams were scored with either a pass or a fail based on two quantitative criteria, both of which had to be met for a pass: efficacy ≥70% and reliability ≥75%. Safety to tortoises remained a qualitative criterion. To establish whether or not a team met the quantitative criteria, field technicians used telemetry equipment and wore headphones to verify that a tortoise was present when handlers stated they had located tortoises. The following data were collected each time a handler stated "tortoise," indicating a find: dog or handler find; if dog find, whether or not the dog performed the sit; whether or not a tortoise was present; if so, transmitter frequency; and time. When the handler completed the search and exited the pen, the

clock was stopped or the exercise was stopped at 60 minutes. Efficacy and reliability were then calculated. For the qualitative safety metric, the following criteria were used: no permit violation (harm to a tortoise); leash not dragging on the ground; handler maintains contact with leash at all times; dog does not dig; and team operates as an operational team.

All but one team received a pass in this assessment; the team that did not pass did not meet the reliability threshold criterion. All teams maintained safety.

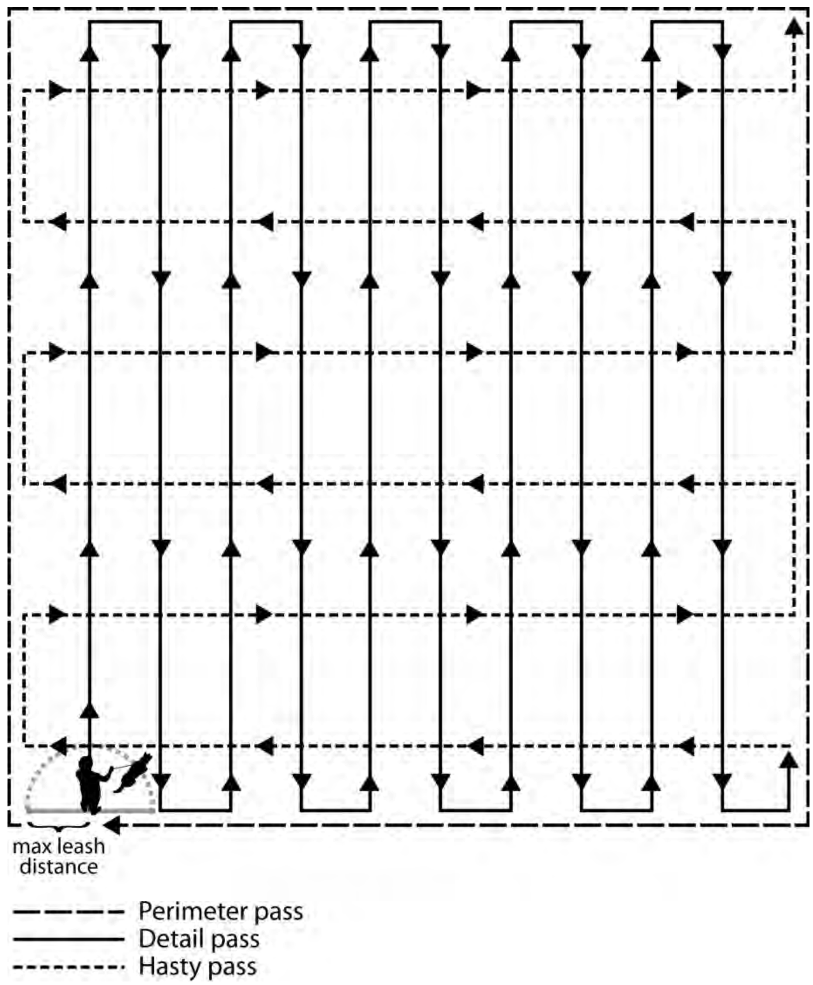

Figure 23. The three-pass search strategy deployed for tortoise searching optimizes searching for moving targets.

Baseline 3 – Low Density Search Environment

The other extreme condition that occurs with desert tortoise surveys is very low densities or areas devoid of tortoises. These are difficult conditions to work in, and the low density assessment was designed to demonstrate that DTK9 teams could remain effective under such circumstances. In the low-density assessment, each team searched a 2 ha area of desert tortoise habitat that was cleared of all tortoises. The handlers were not aware that the areas were not expected to contain tortoises. Upon completing the 2 ha search area, each team was moved to a second area that contained one adult tortoise, unknown to them. The criterion for receiving a

pass was the handler correctly determining the location of the tortoise. A fail was given when the team did not locate the tortoise.

Each handler was provided a 2 ha area with the plot boundaries uploaded to their GPS as waypoints. The handlers wore the GPS with the track log set to “on” and carried with them the following equipment:

- Sufficient potable water for the dog and handler during the survey
- Portable shade for the dog (i.e., umbrella)
- Rectal thermometer in working condition for the dog
- Reward (toy or food)
- Active and passive cooling equipment to include at least 50% alcohol-water mix in spray bottle, ice packs, and shade
- Medical/veterinary care items to include at a minimum forceps, band-aids, gauze, and self-adhering bandage
- Footwear for the dog.

There was a 4-hour time limit to complete the search of the 2 ha area. Each handler was assigned a tortoise biologist who walked along with the team. The time began when the evaluator started the exercise. All teams worked simultaneously in adjacent search areas and executed the three-pass search strategy (Figure 23). The dogs worked on the same leash as in the high-density assessment. Handlers were called from their search area as they approached completion of their area, to search a second area. The team had to identify the presence of the tortoise in the second area, but unknown to them, either via a trained alert articulated by the handler or by the handler recognizing and articulating a change of behavior in the dog that indicated the presence of a tortoise. All but one team received a pass from this assessment. The fail was due to the dog neither alerting on the tortoise nor the handler recognizing the dog’s change of behavior. This was not an operational team in a low-density environment.

Results from the baseline characterization are provided in Table 4. All teams received a pass on the safety evaluation, six teams met or exceeded the reliability threshold, and six teams received a pass for the low-density assessment. Overall, the results of the baseline characterization yielded five teams considered pass and two considered fail. Team 13 was not functional in Read-and-Go. This team did not locate the tortoise after searching for a long time period without a find, and Team 14 was not reliable.

Table 4. Results from the three baseline assessments.

Dog Team	Safety	High Density		Low Density	Overall
	Score	*Reliability*	*Efficacy*	*Functional?*	*Pass/Fail*
7	9	1.00	0.82	Y	P
11	9	0.89	0.75	Y	P
12	-	0.70	0.83	Y	P
13	10	0.82	0.92	N	F
14	9	0.33	0.75	Y	F
15	11	0.78	0.82	Y	P
16	12	0.82	0.92	Y	P

6.3 DESIGN AND LAYOUT OF TECHNOLOGY AND METHODOLOGY COMPONENTS

The monitored adult tortoises residing at the Piute Valley site are wild, free-ranging desert tortoises and their locations and home ranges are well known. Fourteen transmittered adult tortoises at the site (five females, and nine males) were tracked daily during the demonstration. Seventeen tortoises in hatchling and juvenile size classes were transmittered and released among these adults following permit requirements. A total of seven tortoises less than 110 mm MCL and 10 tortoises between 110 mm and 167 mm MCL were released on April 22, 2008 (Figure 24). The number of tortoises of each size released was determined based upon their availability at DTCC and the number of transmittered adult tortoises at the site, where the number of small and medium-size class tortoises released was a proportionate number to match a known wild population (Esque and Duncan, 1985). The study area and survey plots are shown in Figure 25.

Figure 24. Tortoises with transmitters were released into a known wild population of adult tortoises.
Yellow arrow points to small tortoise.

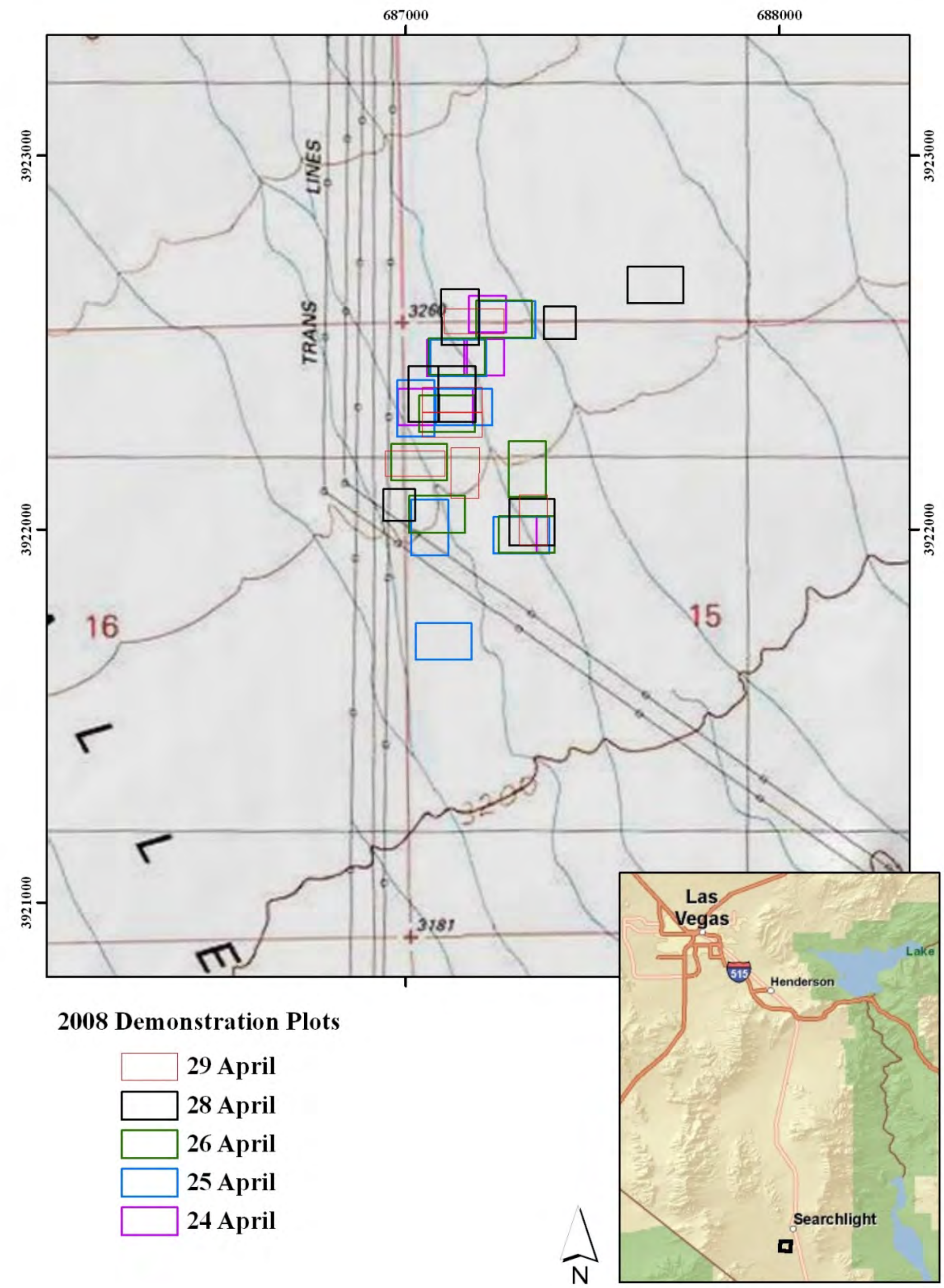

Figure 25. The Piute Valley demonstration area and the location of survey plots by date.

DTK9 team descriptive data with pass/fail status are presented in Table 5. Each DTK9 team was assigned one tortoise biologist. Additional field technicians participated in the daily activities involving calibration and telemetry to locate tortoises daily.

Table 5. DTK9 team data with baseline characterization data is a unique identifier.
F = female and M = male. DTK9 veteran indicates the dog had prior deployment as DTK9. Group identifies pass (P) or fail (F) of Phase I baseline characterization (certification).

Team	Dog Breed	Handler	Dog	DTK9 veteran	Group	Dog age (yrs)
7	GSD	F	F	Y	P	7
11	GSD	F	F	Y	P	10
12	Lab mix	F	F	Y	P	4
13	Australian shepherd	F	M	N	F	5
14	GSD	M	M	N	F	2
15	Hound mix	F	M	N	P	1
16	Labrador	F	M	N	P	2

GSD – German shepherd dog

Handlers carried the required gear as described in Section 6.2 *Baseline 3 – Low Density Search Environment*. Figure 26 shows some of the required equipment deployed during a rest while searching at Piute Valley. The umbrella increases shade, the dog's ears are turned inside out and sprayed with a mist of 50/50 water/alcohol mix, and the handler has ice water for herself and the dog to drink. The dog is wearing protective foot covering and both a flat collar and a training collar. The dogs wore foot covering to protect against the rough and, in places, sharp, desert surface. Typically the dogs wore cotton baby socks which were held in place with self-adhering bandages (Vetrap). An alternative foot protection worn by some dogs were booties made from lightweight 300 denier Cordura fabric attached with Velcro above the dog's wrist, as shown in Figure 27. An ice pack is placed between the flanks of the dog's hind legs where hair is less thick and prevalent. Although not visible in Figure 26, the dog is wearing a harness with GPS data logger attached.

Handlers carried Garmin eTrex Vista GPS units attached to their backpack. Dogs wore 4 in i-Blue 747 Bluetooth data logger GPS receivers attached to their harness (Figure 27). The unit was encased in a Ziploc bag, and the bag was duct taped to the harness. In this manner the GPS antenna was secured in place and provided with maximum sky view with minimum disruption to the dog. These devices have no screen or utility functions like a handheld GPS unit; rather they are solely position logging devices. These units offered advantages for recording dog tracks in their small size and shape, light weight, and the ability to be duct-taped repeatedly to a dog harness.

Figure 26. Required equipment deployed to cool the dog.

Figure 27. The dogs wore an i-Blue 4-in GPS data logger attached to their harness to record dog tracks.

6.4 FIELD TESTING

Once the baseline assessments were completed as described in Section 6.2, field testing commenced. All seven dog teams participated in this demonstration. Field testing during Phase II began on April 24, 2008 and ended April 29, 2008. One rest day was taken on April 27, 2008. On this date no trials were run; however, tortoises were tracked.

Data collection to calculate efficacy and reliability was conducted within search area boundaries, which were delineated based on last known locations of transmittered tortoises. Search area boundaries were delineated to provide comparable distributions of tortoises for each of the three size classes for each of the dog teams.

Each morning the research team and DTK9 teams received their assigned area to survey as indicated by the waypoints in their GPS. Immediately prior to beginning the survey, the dogs were calibrated using tortoises withheld from release and retained specifically for the purpose of calibration. The objective of calibration was twofold: (i) to ensure that the dog was ready to survey as indicated by it performing the sit upon locating a tortoise and (ii) to ensure that the team was operating safely in the presence of tortoises. Teams went directly from calibration to their survey areas and began their surveys.

Teams worked simultaneously and there was no time limit to complete the assigned survey plot. Handlers searched the assigned plots using the three pass grid strategy. GPS tracks were recorded for both dogs and handlers.

Each DTK9 team was assigned a tortoise biologist who wore headphones with the telemetry equipment to immediately validate finds in the field. Surveys were conducted double-blind. Using telemetry equipment, the tortoise biologist could establish quickly and noninvasively the presence of a known tortoise based on frequency (Figure 28). If the telemetry equipment returned no signal from the known tortoise frequencies the tortoise biologist conducted a physical search as would be conducted by a human in a tortoise survey without the use of dogs. In this manner any ‘wild’ tortoises that were not telemetered could be identified and counted. Handlers were not provided with results from their search efforts.

When surveys were completed field personnel tracked and located each transmittered tortoise. These data entered into the geographic information system (GIS) and used in part to guide delineations of the next day’s survey plot boundaries. In addition, the GPS unit data were downloaded and erased from the GPS and data from daily data sheets were entered. DTK9 team assignments for the next survey day were established and corner points were uploaded into the GPS units. On the last day of Phase II (April 29, 2008) when telemetry tracking was conducted, the tortoises that were released for this study were collected from the field and returned to DTCC.

Figure 28. An authorized tortoise biologist verifies the presence of a tortoise using telemetry equipment.

6.5 SAMPLING PROTOCOL

Sampling at Piute Valley was conducted to establish efficacy and reliability under field conditions for expected wild population demography. Other data were also collected that included meteorological conditions during the time teams surveyed assigned areas and time to complete surveys. The amount of time required to complete the survey coverage of the assigned areas was recorded with breakdown of time into the time spent on break (i.e., rest, water, gear adjustment, etc.), the total time worked minus breaks, and total time in the field.

Data were collected when a handler determined that a dog alerted (Table 6). General data included information about the date and time of the alert and identified who the data recorder was by initial. The tortoise information included the transmitter frequency of the tortoise and the unique identification number for that tortoise. Team information was the unique identification number for the team that made the find, the handler's last name, and the dog's name. Redundancy in the collected data was for quality assurance and control. Behavioral information about the find itself was also collected and included whether or not the dog indicated (alert); the type of reward to the dog (full, pet, or none); whether or not the dog performed an independent or a dependent alert; whether or not there was physical contact between the dog and tortoise and, if so, what type; whether the find was by the dog or the handler; and whether or not the handler knew the tortoise was present at the time of the find. Sometimes the dog's behavior draws the handler's attention to the tortoise and the handler is able to see the tortoise immediately prior to the dog alerting. Location data were collected where the tortoise was located as Universal Transverse Mercator (UTM) coordinates. The configuration of the tortoise (surface, shrub, or burrow) was recorded. Data recorders also recorded the degree to which a shrub or burrow was

able to be completely searched by a human based on the dog's alert. Confirmation data included whether or not the alert was confirmed to indicate a tortoise (verified), the method of confirmation (visual or frequency), and if the tortoise was known or unknown, based on it being one of the released tortoises or a wild tortoise.

Table 6. Data collected when a handler determined the dog alerted.

General	Tortoise	Team	Behavior	Location	Confirmation
Date	Frequency	Unique ID	Alert	Configuration	Verified
Time	Unique ID	Name	Reward	Search-ability	Method
Recorder		Dog name	Cue	UTM X	Type
			Touch	UTM Y	
			Interaction		
			Found by		
			Disposition		

A nearby meteorological station that was used for other tortoise monitoring in Piute Valley was used to collect data on relative humidity, temperature, and wind speed. The UTM location of this station was 11S 686588E, 3920006N. Data were collected and averaged at 15-minute increments.

6.6 SAMPLING RESULTS

During the 5 days of field trials in Piute Valley, a total of 75 tortoise finds were possible. Tortoises move and thus the actual distribution of tortoises often changed before the dog teams began their search effort. Using a combination of the location where tortoises were recorded the day prior to searching, tortoise locations during finds, and tortoise locations during the final telemetry at the end of each day, the number of tortoises per size class available for each dog to find was calculated. The rule base to establish whether or not a tortoise was missed by a DTK9 team was that the tortoise had to be present in the search area the day prior and the day of the survey as established by telemetry. Only tortoises located within the search areas counted as a find. These data are presented in Table 7. Expected and actual distributions differed because tortoises move. Table 8 shows the results of the numbers of tortoises located grouped by pass dogs and fail dogs. Efficacy and reliability by team are presented in Table 9. The two teams shown in red were considered failed and did not meet the criteria.

Table 7. Expected and actual count distribution of tortoises available to be found by each team over the course of the field trials.

	Tortoise Size Class – Designed			Tortoise Size Class - Actual		
Dog team	*Small*	*Medium*	*Large*	*Small*	*Medium*	*Large*
7	3	5	2	6	10	2
11	6	9	5	1	6	1
12	3	6	1	4	5	2
13	4	9	2	4	8	3
14	4	4	5	3	6	1
15	6	6	1	4	3	1
16	5	4	1	3	1	1

Table 8. Number of tortoises in each of the three size classes located by the dog teams, grouped by either having passed or failed the baseline assessment.

	S	M	L	Total
(5) passed dogs	18	25	7	50
(2) failed dogs	7	14	4	25
total	25	39	11	

Table 9. Sampling results from the Piute Valley demonstration.

	Reliability	*Efficacy*
Criteria	0.75	0.70
Dog Team	*Reliability*	*Efficacy*
7	1.00	0.88
11	0.88	0.84
12	1.00	0.88
13	0.86	0.47
14	0.00	0.40
15	0.78	0.91
16	1.00	1.00

Table 10 shows the time to complete the search of the assigned survey area by team for each date of surveying and includes the time spent working (total time minus break time) and the total time in the field. Teams searched ~1.5 ha per day. The DTK9 teams completed this size area between 3 and 5 hours, including breaks. The actual time spent searching, less break time, was approximately 3 hours. The variability in total work was team-dependent and is a function of the dog and handler need for breaks. Track data from a dog GPS is illustrated in Figure 29.

Table 10. Time data recorded per plot per day.
No data = no data available. N/A = team did not work that date.

	Work time minus break time (hh:mm)/Total time worked by team (hh:mm)							
	7	**11**	**12**	**13**	**14**	**15**	**16**	**Mean**
23 April[1]	4:38/5:34	No data	N/A	5:06/6:07	4:22/5:45	6:21/7:09	5:56/7:20	5:17/6:23
24 April	3:24/4:05	2:06/3:09	N/A	2:36/2:58	3:39/2:45	3:32/3:54	4:14/6:13	3:15/3:50
25 April	3:39/4:43	2:20/3:12	3:43/5:04	4:36/7:03	3:03/4:59	4:00/5:03	2:40/4:10	3:25/4:53
26 April	4:12/4:55	2:16/2:34	2:55/3:46	2:43/3:03	3:25/4:16	4:50/5:15	3:14/5:23	3:22/4:10
28 April	N/A	2:41/3:23	3:54/5:15	3:03/4:00	2:24/3:03	2:24/4:48	2:51/6:04	2:52/4:25
29 April	N/A	2:13/3:47	No data	3:26/3:35	2:41/4:16	4:51/5:14	2:59/5:00	3:14/4:22
Mean[2]	3:20/4:34	2:24/3:13	3:31/4:41	3:17/4:02	3:02/3:52	3:55/4:57	3:12/5:22	

[1] On this date the teams searched 2 ha plots. Subsequent plots were 1.5 ha.
[2] Calculated for April 24-29 with comparable search area sizes.

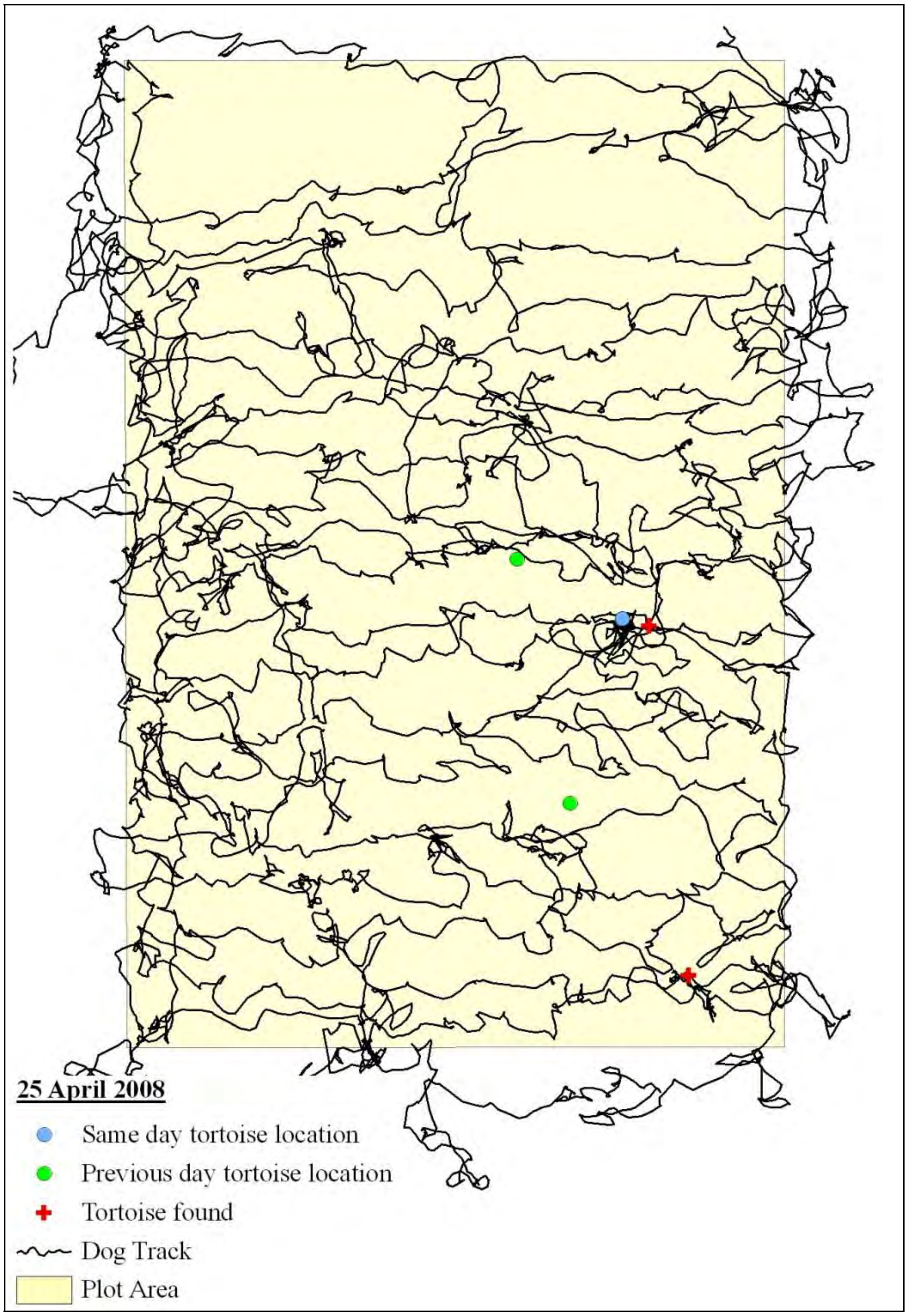

Figure 29. Example of track data downloaded from a dog GPS data logger.

Meteorological data collected during the time period that the DTK9 teams were actively surveying in assigned areas in Piute Valley are presented in Table 11. Ground and surface temperature are presented in graphical format to show daily trends in Figure 30 and Figure 31, respectively. Ground temperatures increased over the working time period at similar rates; however, temperatures increased earlier in the day as time progressed from the 23rd of April to the 29th of April. Air temperatures exhibited a similar trend with the exception of a large rise in temperature between the 26th of April and the survey dates, April 28-29.

Table 11. Meteorological data collected at 15-minute increments (average) for the time period the DTK9 teams were actively surveying assigned plots in Piute Valley.

	Ground Temp		Air Temp		Wind Speed	
23-April-08	°C	°F	°C	°F	m/s	mph
min	17.84	64.11	19.27	66.69		
max	39.31	102.76	27.27	81.09		
mean	31.82	89.28	23.86	74.94	5.15	11.52
std dev	6.39	43.51	2.00	35.60	0.92	2.07
24-April-08	°C	°F	°C	°F		
min	15.98	60.76	17.16	62.89		
max	37.66	99.79	25.30	77.54		
mean	29.57	85.22	22.33	72.20	4.66	10.42
std dev	7.43	45.38	2.67	36.80	0.59	1.33
25-April-08	°C	°F	°C	°F		
min	15.27	59.49	17.86	64.15		
max	42.50	108.50	29.07	84.33		
mean	32.72	90.90	24.86	76.74	2.57	5.74
std dev	9.30	48.75	3.82	38.88	0.57	1.26
26-April-08	°C	°F	°C	°F		
min	15.95	60.71	19.64	67.35		
max	38.16	100.69	27.64	81.75		
mean	27.44	81.40	24.17	75.51	4.92	11.00
std dev	7.62	45.72	2.67	36.81	0.45	1.00
28-April-08	°C	°F	°C	°F		
min	12.85	55.13	14.97	58.95		
max	38.08	100.54	31.62	88.92		
mean	25.41	77.74	26.79	80.23	2.16	4.83
std dev	8.60	47.49	4.51	40.12	0.95	2.13
29-April-08	°C	°F	°C	°F		
min	17.76	63.97	20.52	68.94		
max	40.43	104.77	32.84	91.11		
mean	28.43	83.18	28.31	82.95	2.89	6.47
std dev	7.82	46.08	3.89	39.01	1.40	3.14

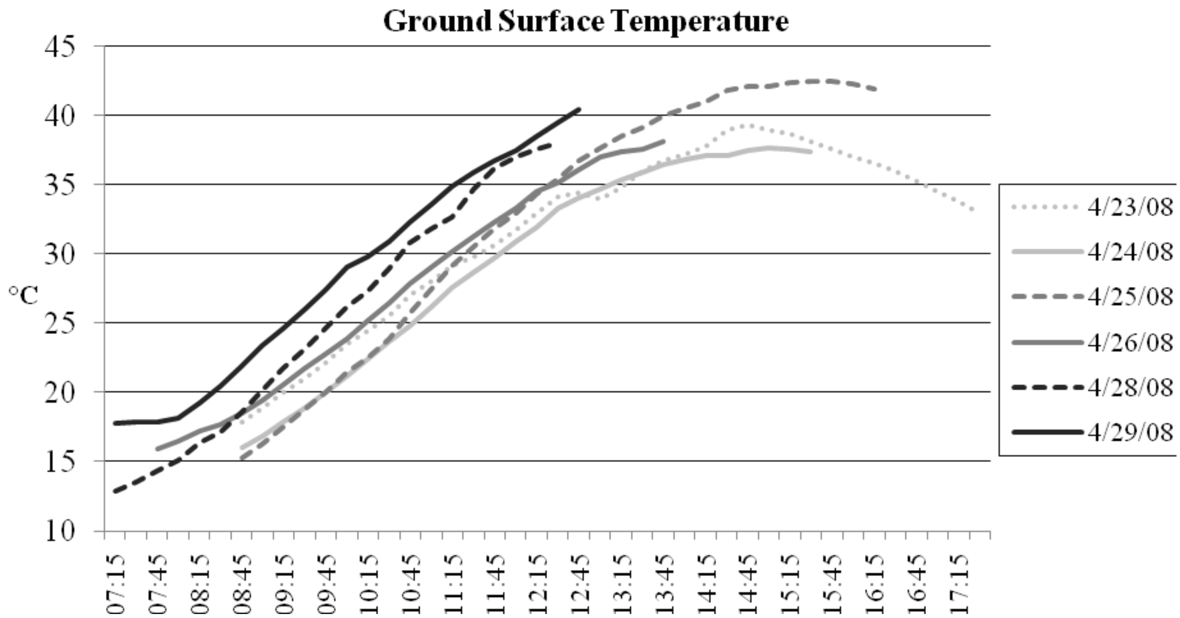

Figure 30. Ground surface temperature data during the time periods DTK9 teams were conducting surveys at Piute Valley.

The time period begins with the first team starting their search and ending at the time that the last team completed their search effort.

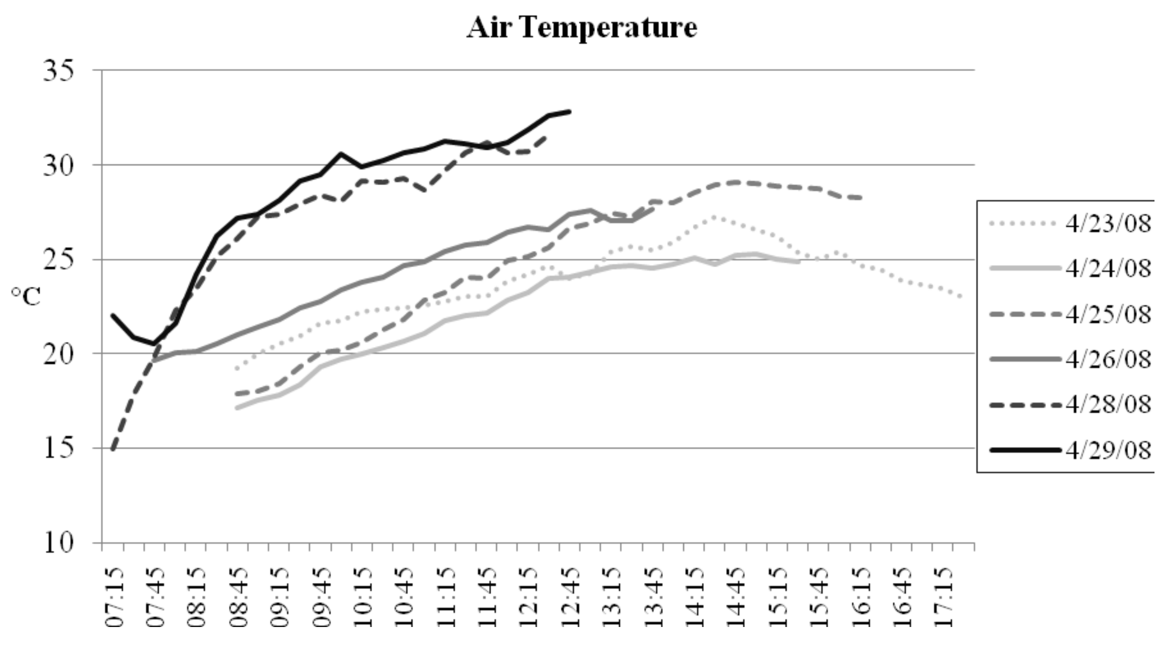

Figure 31. Air surface temperature data during the time periods DTK9 teams were conducting surveys at Piute Valley.

The time period begins with the first team starting their search and ending at the time that the last team completed their search effort.

7.0 PERFORMANCE ASSESSMENT

A total of five performance objectives were set, both quantitative and qualitative. All were met or exceeded. Results showed that the certified DTK9 teams were able to exceed the set performance metrics, which would be useful for setting expectations in future applications of the technology. Improvement in DTK9 team performance was shown from previous work conducted in 2006 at military installations in the Mojave Desert of California (Cablk et al., 2007; Nussear et al., 2008).

7.1 CERTIFICATION TEST YIELDS TEAMS THAT PERFORM TO STANDARD

The first quantitative performance objective established that the certification test, which consisted of three separate assessments fully described in Section 6.2, yielded teams that performed comparably under natural field conditions. This metric, established to determine whether or not the certification tests were effective, was evaluated by direct comparison of capability results during the Phase I assessments to Phase II performance in the field at Piute Valley.

To establish whether or not the efficacy and reliability success criteria were met, data were collected and analyzed on all tortoise finds during the certification tests as described in Section 6.0. Regardless of whether or not the team was considered passed or failed, they fielded during the field trials in Piute Valley. Teams were never told whether they had passed or failed to prevent bias in the resulting data. Table 12 shows the data results from the DTCC certification assessment for high- and low-density tests and the resulting capability for each team's performance at Piute Valley. Threshold criteria in certification tests were 70% efficacy and 75% reliability. Overall, the teams that passed the certification test had an average of 90% for both efficacy and reliability whereas the teams that did not pass the certification test collectively returned only 50% efficacy and 44% reliability during the field tests at Piute Valley.

The results also show an increase in performance for those teams that passed between DTCC and Piute Valley. Efficacy scores increased for each team. Reliability remained comparable for two teams, increased for two teams, and dropped by 1% for one team. All the passed teams represent high efficacy/high reliability cases.

The DTK9 Teams 13 and 14 were deemed failed for different reasons. Team 14 met the efficacy threshold under the high density assessment but did not meet the reliability criterion. The results at DTCC corroborated performance under the stress of working in the natural environment. The dog in Team 14 went on to have a 0% reliability score at Piute Valley. The dog never performed its trained alert at Piute Valley without a cue from the handler. Although Team 14 did meet the efficacy score under the high density scenario, they only found 40% of the tortoises during the Piute Valley demonstration. It is possible that the dog did find more than 40% of the tortoises but, because it was not reliable at communicating finds to its handler, those tortoises not visible were missed. This team represented a low efficacy/low reliability case. For Team 13 the reason for certification fail was that this team did not pass the low-density assessment despite passing the high-density assessment. This team went on to have a low efficacy score in Piute Valley, and when the dog did find a tortoise it alerted with 86% reliability. This team represented a low efficacy/high reliability case.

The results of this performance objective showed that the combination of assessments (safety, high density, low density) that formed the certification test yielded teams that performed comparably under actual working conditions. Teams that passed the assessment criteria went on to perform successfully in the field while teams that failed the assessment criteria did not perform successfully in the field. This was an important metric to demonstrate that the test is effective. It essentially weeds out teams that do not find tortoises under the stress of the real working environment and does not exclude teams that would actually be capable in the field setting.

This criterion was met.

Table 12. Results of certification test utility to produce capable teams.

	Reliability	*Efficacy*		*Reliability*	*Efficacy*
Criteria	0.75	0.70	Functional?	0.75	0.70
	High-Density Assessment		**Low-Density Assessment**	**Piute Valley Field Trials**	
Dog Team	*Reliability*	*Efficacy*	*Y/N*	*Reliability*	*Efficacy*
7	1.00	0.82	Y	1.00	0.88
11	0.89	0.75	Y	0.88	0.84
12	0.70	0.83	Y	1.00	0.88
13	0.82	0.92	N	0.86	0.47
14	0.33	0.75	Y	0.00	0.40
15	0.78	0.82	Y	0.78	0.91
16	0.82	0.92	Y	1.00	1.00

7.2 CAPABILITY-FINDING TORTOISES OF ALL SIZE CLASSES

This performance objective was designed to establish the capability of DTK9 teams to find tortoises of all size classes and was also used to support the analysis of the certification performance objective (Section 7.1). The metrics used to establish capability are efficacy and reliability. The success criteria were established based on past field experience of the research team in quantifying capability for individual size classes over prior years. Degree of difficulty to locate tortoises of different size classes is reflected in the minimum efficacy thresholds, which were established at 50% for small, 60% for medium, and 70% for large tortoises, respectively. Efficacy results from Piute Valley are presented in Table 13. Reliability is independent of efficacy and is expected to be maintained at a minimum level of proficiency, regardless of the tortoise size or location. Reliability was also determined based on past years of experience and was set to 75%. Reliability by team is presented in Table 12.

The DTK9 teams that passed the certification test exceeded minimum criteria for each of the size classes. They were 28% more effective at finding small tortoises, 36% more effective at finding medium tortoises, and performed 30% better for adult tortoises than previously shown under natural field conditions (Nussear et al., 2008). Although the passed dog teams scored a 100% find rate for adult tortoises, it is not expected that a perfect find rate might become a revised standard. In addition to exceeding the efficacy criteria, these dogs also communicated finds

reliably to their handler, exceeding the reliability criteria. Both veteran and first season DTK9 teams were successful at finding all size classes of tortoise and performing reliably.

Table 13. Efficacy results summarized by tortoise size and by pass or fail group.

Tortoise size	Small	Medium	Large
Criteria	0.50	0.60	0.70
Dog Teams	**Small**	**Medium**	**Large**
Passed	0.78	0.96	1.00
Failed	0.14	0.50	0.75

In contrast, the two DTK9 teams that failed the certification test met only the large tortoise criterion. These DTK9 teams each found less than half of all tortoises available to be found. Neither would be considered successful under the established performance objective. However, teams deemed certified via the certification assessment were successful and exceeded the performance objectives.

This criterion was met.

7.3 MAINTAIN IN-FIELD CALIBRATION—READ-AND-GO

This performance objective is foundational to capability (efficacy and reliability) under natural working conditions. Capability is in laymen's terms how good a dog team is at finding tortoises and the likelihood of the dog to tell the handler when it has found a tortoise. As with any measuring instrument, calibration is required and with use the tool drifts from its established baseline. This concept applies both to the dog and to the handler. To be able to maintain the dog's alert and to maintain the team's interest and enthusiasm in searching for tortoises over long time periods when it may be days in between finds, in-field calibration is necessary. Although calibration of humans surveying for tortoises is similarly expected, it has not been studied.

As described in Section 3.2, we developed what is considered behaviorally as an intermittent reward system, modified by establishing a rule-base to deliver a variable intensity reward to the dog rather than varying a constant level of reward at random intervals. This method is termed Read-and-Go and was demonstrated effective in earlier project work. Maintaining the calibration of the team in field is measured quantitatively using the reliability metric set to 75% and through efficacy, which shows that the team continues to be effective finding tortoises. The other piece for establishing whether or not the handler is properly executing Read-and-Go is through demonstrating execution of the three levels of reward (full, pet, none).

As described above, data were collected to calculate reliability and efficacy. Those results are presented in Table 12. During the Piute Valley field surveys, data were recorded regarding the level of reward that handlers administered. These data reflected the handler's ability to operate in Read-and-Go, demonstrated by correct execution of the different reward levels. All handlers administered the variable level reward system in the field; however, not all teams performed at the minimum 75% reliability level or met the efficacy criteria. The five teams that passed the certification tests performed above the 75% reliability criteria and also met the efficacy criteria. One of the failed teams also met the reliability criteria but did not meet the efficacy criteria.

Based on the results of this analysis, Read-and-Go was successful in maintaining the dog's alert in the field setting in six of seven teams. However, we report that only those teams that were deemed certified and thus considered a DTK9 team were able to meet the Read-and-Go performance objective. This further supports the validity of the certification tests to produce DTK9 teams.

This criterion was met.

7.4 SAFETY

Arguably the most important of the performance objectives, and certainly from a permitting perspective, is safety. While one cannot guarantee that no harm will come to a tortoise, in the context of developing a means to survey a protected species the likelihood that harm will be incurred from the survey tool is expected to be minimized. For this reason safety was established as one of if not the primary metric and was measured based on permit violations. The established metric was that no permit violation could occur that could not be mitigated. The data requirements included tortoises and dogs with access to tortoises. Success was determined by the project continuing through to completion without being shut down due to permitting issues.

During the course of this demonstration we did have a permit violation that was the result of a vehicle running over two wild hatchling tortoises at DTCC. Fencing at DTCC has been inadequate to constrain tortoises. Tortoises in the outdoor pens also reproduce freely and without knowledge of DTCC staff as to where nests are located and when they hatch. Although at the time of writing this report, DTCC has changed management and husbandry issues are among the many aspects being revised, during the time period when RC-200609 was at DTCC, tortoises of all sizes regularly escaped outdoor pens. The permit violation during this demonstration was mitigated by capturing and moving the remaining hatchlings that could be found in the area and a minimization of vehicular traffic. Further safety precautions were also added to daily routines while at DTCC. It should be noted that no violation was reported due to a dog-tortoise encounter.

This criterion was met.

7.5 OPERATE EFFECTIVELY UNDER EXPECTED FIELD CONDITIONS

The single qualitative performance objective was to demonstrate that the DTK9 teams were able to field and search under actual deployment conditions. This criterion was established based on prior expertise fielding DTK9 teams at NTC Fort Irwin and EAFB. The criteria for success were twofold: (i) the teams were able to complete their search areas in one day and (ii) data were collected from the surveys to create a database for analysis. Table 10 shows the amount of time to complete the search of the assigned survey area by team for each date of surveying, and includes the time spent working (total time minus break time) and the total time in the field. The search strategy employed was the three-pass grid strategy involving a search first of the perimeter of the area followed by a detailed search in the area directing the dog to sniff all shrubs and possible burrows, and finished with a last hasty orthogonal grid search over the area. This strategy was shown in Figure 22. However, the metric for this objective was demonstration of at least one pass through the search area. As described above, both the dogs and handlers wore GPS units during the demonstration at Piute Valley. Tracks were evaluated each day to determine if

the handler had covered their search area with at least one pass. All teams were able to accomplish this.

The second metric was the completed data sheets for each team at the end of each survey day. A complete database was built based on the Piute Valley field data collected (Table 6). This database supported all other quantitative metric evaluation. Handlers completed at least one pass through their search areas each day, and most of the time they were able to complete all three passes, the standard search strategy for tortoises.

This criterion was met.

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8.0 COST ASSESSMENT

8.1 COST MODEL

The cost of a DTK9 team is dynamic and subject to market forces. At present there has yet to be an assessment of other survey technologies to the level conducted under ESTCP RC-200609 demonstrating comparable ability to locate all size classes of desert tortoises. As such the benefit of this technology to its demonstrated level is unique and it is difficult to place relative value estimates on DTK9 teams. Without an equivalent rigorous study for human performance, there is no means to conduct a direct cost comparison for the same capability. In RC-200609 we relied on the use of transmitters and telemetry to validate dog finds to be able to conduct capability assessments. There were instances when the dogs alerted and small nontransmittered tortoises were validated by the tortoise biologists as well as instances where alerts could not be validated. Without having transmittered the population for this demonstration, the use of humans alone to validate dog finds would have required extensive time and personnel resources without a guaranteed return.

The cost to field a DTK9 team follows a pricing structure that models the costs to field human survey teams. To date dog handlers have not been permitted to handle tortoises so permitted tortoise field technicians would be necessary for data collection. Dog handlers who are also permitted to handle tortoises would potentially not require an additional technician to be part of their team and would thus reduce costs. Cost estimates for the elements associated with DTK9 teams during the demonstration are provided in Table 14. These estimates were based on the most current information available and actual costs during the demonstration, whichever were more current. This is due to changes that occurred after the demonstration was completed.

The expected overall implementation costs will be less than those tracked during the ESTCP demonstration because the research and development aspects would no longer apply. The principal investigators, data technicians, and master trainer, for example, are not required elements of DTK9 teams as a stand-alone technology. Critical elements of implementation were specifically tracked for use in providing realistic estimates to technology end users. The degree to which costs beyond the direct cost of a DTK9 team and field technician applies will vary with the scope of the project. For example, the cost of permitting may not apply solely to the DTK9 portion of a project as the use of DTK9s as a survey tool may be one of many permitted aspects. The costs listed in Table 14 are detailed as follows.

The DTK9 team is the technology and is the most costly element. This cost included all dog and handler expenditures such as food and veterinary care as well as personal dog gear not specifically provided for the demonstration (i.e., GPS, data loggers). Travel costs for handler to participate in training and testing activities were reimbursed at allowable federal per diem rates. Reimbursement to handlers was conducted on a task-specific scale. There was an opportunity cost to handlers participating in this demonstration and that is reflected in the reimbursement rate for training at DTCC and for non-working days during the field demonstration at Piute Valley.

Table 14. Cost model for DTK9 teams based on expenditures from 2008 demonstration.

Cost Element	Data Tracked During the Demonstration	Actual Costs
DTK9 team (each) without permitted biologist	Daily cost per type of task	• $0 scent recognition training off-site • $200/day training at DTCC • $400/day working • $200/down day
Permitted biologist for DTK9 team	From Nussear et al. (2008)	$176/day
Facility Fee (DTCC)	N/A	N/A
Training/testing by master trainer	Cost to conduct individual team training, maintain training schedule, and oversee safety for dog-tortoise encounters at DTCC	• $450-$600/day during training for ≤ 8 teams • DTCC personnel costs unknown
Travel, lodging, and per diem	Federal per diem rate for Las Vegas, NV	• $183/day (average) • 0.55/mi federal rate
Permitting fees	Fees paid for state (1) and federal (1) permits	$200

Initial scent recognition training was done without compensation to the potential handler; however, initial scent recognition training is expected to be a recovered cost once implemented. The initial cost to train a dog for tortoise detection is a one-time expenditure as it is a one-time event. Maintenance training must be absorbed by the handler unless working on a multiyear project where training can be shown to directly benefit the specific project. It would be expected that a returning DTK9 team would be effective and reliable at the start of the survey season whether maintenance training were conducted over the course of a few months or done intensively immediately preceding fielding (or recertification). Using locally available DTK9 teams will reduce travel and per diem expense associated with any personnel, handler, or otherwise. It should also be noted that handlers received a different rate for days when they were fielding as a DTK9 team versus rest days. It would seem appropriate to negotiate on this rate or to have handlers contribute to the project in ways that do not involve dog-handling for compensation. Dogs do not work on rest days for any purpose.

Typically, the handler is not expected to be permitted to handle tortoises, and during the demonstration this was the case. For the demonstration purposes, the tortoise biologists had multiple duties including data collection and safety responsibilities. During actual surveys by certified DTK9 teams, it is more efficient to have separate roles for the handler and the tortoise biologist. The tortoise biologist processes tortoises while the handler continues to cover the search area. The cost estimate provided is based on published costs in Nussear et al. (2008). The cost for a permitted biologist will vary depending on a number of factors, including the individual's experience, the employing organization or company, and the number of surveys or projects occurring at a given time (supply and demand). Market forces apply to qualified, permitted biologists, which may significantly affect this cost element.

At the time of the demonstration and for all years preceding the demonstration, there was no fee to use DTCC or to receive personnel support. This changed immediately after the demonstration was complete, and new policies and procedures are being implemented. These changes include

the potential for a facility-use fee to be implemented. Included in the fee might also be an expense for DTCC personnel support. At this time the fee schedule is not in place. Future facility use fees associated with DTCC should be included for a realistic cost estimate.

Two permit fees were also necessary to conduct the demonstration. These were for Nevada Department of Wildlife and for the USFWS.

8.2 COST DRIVERS

The main cost driver will be the level of detail that is required of the survey. Surveys that require detailed searches to locate all size classes of tortoises or in particular the smallest tortoises will require approximately 1 dog team per 2 ha per day. Thus a detailed search of a parcel 1 km^2 in area would require 50 dog-team days whereas searching for larger tortoises would require 6 to 10 dog-team days.

The two components of the DTK9 technology that are likely to incur the most cost are the rates charged by the handler/dog teams, and the staffing for the training and evaluation sessions that are to occur on an annual basis, which will be absorbed into the cost estimate for working DTK9 teams. In addition, the cost of human surveyors will affect project costs, as authorized tortoise biologists will be necessary personnel to process (handle, draw blood, attach transmitters, etc.) tortoises. These costs are market-driven. As most users of this technology are expected to be federal agencies, subcontractors thereof, or consultants to developers conducting surveys, contracts of this type would be expected to be of a cost that must be put out for bid. As such the rates charged by handlers may be driven by this process through market competition.

Staffing required to train and evaluate dog teams on an annual basis will likely require flexible staffing numbers, as the numbers of DTK9 teams that will need to be processed will vary based on the anticipated number of surveys to occur in the following year.

8.3 COST ANALYSIS AND COMPARISON

Operational implementation of DTK9 teams will involve certification, permitting, and field costs, including travel. These costs are provided in Table 15. The cost estimate for certifying DTK9 teams is based on the only facility currently available to provide the full complement of size classes of tortoises, DTCC. Initial training on adult tortoises might be possible using captive pet tortoises; however, this would not represent a complete odor signature for the dog, as demonstrated through RC-200609. For these reasons at this time all testing would be conducted at DTCC in Las Vegas, NV, and the cost estimate reflects this.

The cost estimate assumes teams will field for surveying for the Mojave Desert tortoise and as such costs are not expected to vary with site throughout the range of the Mojave Desert tortoise. Coverage by DTK9 teams would decrease with increasing landscape complexity, just as it does for human-based surveys. The more complex the terrain, the more locations needed to be closely inspected and thus the longer search time and effort required. This would vary more when searching for small tortoises than for larger tortoises. Fielding teams to locate Sonoran populations of desert tortoises may require additional training and testing as suitable habitat tends to be of a different character than in the Mojave.

The cost analysis assumes similar cost elements and extent of survey area coverage as that documented during RC-200609. It also assumes that variable rates such as per diem, travel, organization overhead, other internal operating costs, and fixed costs will vary with location of project, project extent, project scope, and the particular organization or company doing the work, among other factors, and will be incurred regardless of whether the survey resource is human or DTK9.

Table 15. Cost model for DTK9 teams based on expected costs provided by consultants and revised DTCC facility fee schedule.

Cost Element	Estimation Basis	Estimated Cost
Dog/handler team (each)	Estimates made based on 2010 cost estimates from consultants[1]	• $1725 basic training off-site[2] • $242/day training at DTCC[3] • $483/day working[4] • $230/non-working day
Facility fee (DTCC)[5]	USFWS-provided estimate	• Undetermined yet
Training and testing to the DTK9 standard	Cost to certify teams for permitting[6]	• $600/day during training for ≤ 8 teams (master trainer) • $176/day field assistants[7]
Travel, lodging, and per diem costs	Federal per diem rate[8]	• $183/day (average) per diem for Las Vegas • 0.25/mi to 0.50/mi federal mileage reimbursement
Permitting fees	Fees paid for state and federal permits	• $200 (federal and one state)

[1] Cost estimates provided by PackLeader Dog Training and by Working Dogs for Conservation. Both organizations are businesses that provide wildlife detection dog teams.
[2] For first-time dog needing scent recognition training for tortoise
[3] Tortoise training for transitioning to live animals and/or refresher training for veteran team on live animals
[4] For a certified team working in the field surveying for tortoises
[5] This is a new fee since conducting the demonstration.
[6] Research and development cost, expected to be less upon implementation because the program and its material have been developed.
[7] Based on estimates from Nussear et al. (2008). Consultant cost could be 2-4 times higher with market forces.
[8] This rate will vary with location and time of year. Use of local teams will minimize per diem costs.

Human surveyors permitted to conduct desert tortoise surveys must be trained as well. A cost accounting of training and testing of humans is unavailable. To conduct surveys as a desert tortoise authorized biologist requires extensive experience handling and receipt of training under authorized tortoise biologists. Application requirements include certification of total time spent conducting authorized and supervised tortoise activities, miles/kilometers walked, handling of wild tortoise by size, coursework, field training, and translocation activities, among others (http://www.fws.gov/ventura/speciesinfo/protocols_guidelines/). In addition the USFWS (2010a) reports, human surveyors undergo 5 weeks of training prior to conducting LDS surveys. Human surveyors conducting surveys that involve health assessments, such as translocation projects, must undergo additional training. This includes health assessment training ($1500 for a 5-day rotation) and drawing blood ($1800 and an additional 5-day rotation) (USFWS, 2010b). Attaching transmitters to tortoises or conducting other procedures requires additional training and associated cost. The USFWS reports survey costs to conduct LDS for fiscal year 2011 at $1,074,300, of which DoD is expected to contribute $300,000 (http://www.fws.gov/nevada/desert_tortoise/documents/recovery_plan/20110310.Desert.tortoise.monitoring.coop.venture.pdf).

Life-cycle costs for DTK9 teams directly relate to the age at which the dog starts training for desert tortoises, becomes certified, and the age at which the dog retires. Other factors for life-cycle cost include the number of other target odors the dog is trained to and actively works, and how much of the non-tortoise survey season the dog works for detection. Working dogs typically begin training when acquired, which can be as early at 8 weeks old. The amount of time before a dog is considered field ready and certified, where standards exist, varies with the skill level of the trainer/handler and the ability to conduct necessary training. A dog can begin working as part of a certified team by the time it is a year old assuming professional training began early in the dog's life. The length of time a dog works over its lifespan varies tremendously. Injuries can end a dog's career at a relatively young age, and at the same time, one of the DTK9 dogs continued to work at age 13, although this would not be considered typical. In terms of estimated life-cycle cost of the technology our research has shown that once the dog learns tortoise as its target, minimal retraining is necessary prior to beginning a new field season. Furthermore, when a dog continues to work locating other non-tortoise targets in off seasons, the detection and alert behavior is reinforced, which translates across its recognized target odors. Searching and training for other targets helps maintain the dog in working condition. Therefore the estimated cost to maintain the dog as a tortoise detector over the course of its life, even while not searching for tortoises, can be minimal. There is no associated cost for a DTK9 team to survey for targets other than tortoises. The annual cost to maintain the DTK9 varies with demand in any particular year. As training and evaluation requirements are likely to persist from year to year, the costs per DTK9 team that passes the certification are not expected to change markedly throughout the lifetime of the team.

Unlike a mechanical device, a trained detection dog does not depreciate with time. Rather it may actually appreciate in value because the dog learns and learning translates directly into the dog's capability with each field deployment. The more repetitions in reinforcement with reward, which would be expected to occur during field surveys, the 'better' the dog becomes. An experienced dog actually increases in value and requires less maintenance over time, which results in lowered annual costs.

The use of DTK9 teams is not intended to replace existing survey means, particularly since the search strategy for an olfaction-based detection tool differs from a visual tool. The DTK9 development was conducted to provide an additional survey tool and specifically to add utility by focusing on small tortoises. For example, DTK9 teams may serve to enhance existing human-based surveys in instances where human survey data indicates the presence of smaller tortoises might be expected. The 2005 "human-DTK9 comparison" was designed to be a direct comparison of the effectiveness and cost of human survey teams compared with dog survey teams, and it was anticipated that small tortoises would be found by both teams. When results did not yield small tortoises, additional effort was conducted to further investigate dog capability, specifically for small tortoises, which ultimately resulted in the advancements and technology development outlined here. However, no additional efforts were conducted for further training or assessment of human survey teams. To this end there exists a void in baseline capability against which to compare existing visual (human) survey methods with the DTK9s. It is possible that a combined effort of human and DTK9 search teams could be deployed, but it is unknown whether doing so would result in significant cost savings.

Interpretation of the cost to obtain and deploy a DTK9 team as well as how to scale the costs would be done with respect to the physical size of the area to be surveyed for desert tortoises and the level of detail desired. Results from RC-200609 and previous studies have shown the expediency of DTK9 teams to cover an area. There is a direct relationship between the speed of the team and the size classes they can effectively detect. Therefore to conduct more thorough surveys requires additional time as the size of the search area increases. Contracting more teams enables larger areas to be surveyed with sufficient detail. As would occur with any tool, costs will increase with the number of teams and with the amount of time teams spend working. The objectives of the survey would dictate whether to field fewer teams over more days; field more teams over fewer days; relax the size constraint of the tortoises to be detected; or employ stratified sampling to focus more intensive effort.

Previous cost estimates for human teams in Nussear et al. (2008) were based on limited student and government labor rather than contractor costs. Contractor-based costs could be up to four times or more depending on market forces. Table 16 presents a revised cost comparison for human-only teams and DTK9 teams for two levels of survey effort based on tortoise size class and based on area to be covered. These estimates are based on survey team sizes from the 2005 human-DTK9 team comparison with revised cost estimates for both human contractors and current DTK9 rates. The costs assume that preparatory training and permitting are in place and are thus not included. Support and logistic personnel would be expected to be similar as the scope of the project increased for either type of team. In 2005, six DTK9 teams were deployed to cover 1 km^2 per day with one authorized tortoise biologist accompanying each team. Based on improvements in training and deployment parameters, it would be feasible to have fewer tortoise biologists on call (roving or strategically located) to respond to a dog alert within a 1 km^2 area when searching for tortoises $\geq$180 mm MCL. Completing a survey of 50 km^2 per day would be an ambitious undertaking for either survey method.

Because previous work has shown that a team of 11 humans without scopes but with mirrors and probe poles were unsuccessful at locating small tortoises, assumptions must be made to conduct a direct cost-comparison for the full desert tortoise demographic (Nussear et al., 2008). In this same study, DTK9 teams were equally deficient; however, results from RC-200609 resolved this problem and resulted in area-effectiveness rates for DTK9 teams. The 11:6 ratio for human to DTK9 teams therefore requires modification for a cost comparison. When conducting surveys to include smaller desert tortoises, one DTK9 team can effectively cover 0.015 km^2 per day. Using straight scaling based on the area-effectiveness of DTK9 teams, 122 humans would be needed to cover 1 km^2 for all size classes assuming more people result in improved detection. For this type of survey, each DTK9 team should have an authorized tortoise biologist accompany them. For humans, adding the use of scopes and assuming the surveyors are trained and proficient with this tool, might serve to increase find rates. Using scopes increases the amount of time required to cover an area, which would dictate increasing the team size to complete an area within one day. In the 2005 study, the humans searched an average of 8.52 hours per day. The same number of humans could be tasked to survey 12 or more hours a day, or more people could be added to the survey team; both options will reflect cost increases and requiring such concentrated effort for increased hours may be ultimately counterproductive to the task at hand. For simplification, Table 16 uses a multiplier of 1.5 to accommodate the level of effort to effectively use burrow scopes and to conduct a thorough search for small desert tortoises without increasing the number of hours each person would spend surveying.

Table 16. Cost comparison of human survey teams and DTK9 teams.
Estimates presented represent the number of teams to cover the specified area in a given day. (m=million)

	Tortoises ≥ 180 mm MCL			Tortoises < 180 mm MCL		
Team	**Area (km^2)**	**Count[1]**	**Total cost/day**	**Area (km^2)**	**Count**	**Total cost/day**
Human	1	11	$4840-7744	1	183	$80,520-128,832
DTK9	1	10[2]	$4658-5714	1	67	$61,841-79,529[3]
Human	50	55	$24,200-38,720	50	9,150	$4.026m-6.442m
DTK9	50	50	$23,290-28,570	50	3,350	$3.093m-3.977m

[1] Number of humans or DTK9 teams + tortoise biologists
[2] Six dog teams would rely on four authorized tortoise biologists to process tortoises found.
[3] Calculated for one authorized tortoise biologist accompanying each DTK9 team

Surveying 50 km^2 in one day for all size classes of desert tortoise is unlikely given the resources required. There might also be concern for environmental consequences of fielding such a large number of people in a given area as the desert can be susceptible to foot traffic. This cost comparison shows that DTK9 teams are not necessarily cost-prohibitive or more costly than human survey teams alone. Market cost for authorized tortoise biologists drive the cost estimate.

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9.0 IMPLEMENTATION ISSUES

9.1 REGULATIONS AND PERMITTING

Regulations and permits related to the implementation and deployment of DTK9 teams are primarily related to the protection of desert tortoises and their habitats and the specific concerns for lands set aside for particular management prescriptions for tortoises and their habitats or otherwise. As with any survey conducted for federal or state listed species, permits to interface both humans and dogs will be required. The permit process for the human side of deploying DTK9 teams is the same as for any other permit involving human-based surveys. For interfacing the dog side of the DTK9 team, we recommend that permitting agencies look to the certification standard developed as part of this demonstration (Cablk and Harmon, 2011). Surveys have been conducted in the Mojave using dogs without acquiring permits prior to RC-200609. Based on the results presented here, we do not advocate continuing this procedure.

Table 17 presents the permits, agency, and pertinent regulations that would be anticipated for fielding DTK9 teams. Several of these permits may be required simultaneously for the legal use of DTK9s to search for desert tortoises. Any possibility of "take" of an endangered species or their habitats requires the issuance of an endangered species permit under the ESA (1973). State wildlife permits and coordination will be necessary for the states where the projects will occur. Each state where the tortoise is protected by federal law also has its own regulations to protect listed species, and the regulations require the acquisition of a scientific collection permit for work with desert tortoises. Sufficient lead time is required by these agencies comparable to that required for the federal permit.

Other federal, state, county, municipal, or private entities may legally require permits to enter their jurisdictions and these may be based on regulations requiring scientific collection permits, cooperative agreements, or letters of permission. Suffice it to say that land ownership should be considered for all DTK9 activities and owners should be contacted to ensure that regulations are being adhered to. Finally, in addition to responding to land-based regulations, research projects in cooperation with state universities often require Animal Care and Use Committee (ACUC) coordination for the use of dogs in research projects for the protection of wildlife and the dogs.

The following guidance is provided to illustrate examples of why the regulations are necessary and provide the opportunity to explore potential situations that require consideration in advance of DTK9 implementation. DTK9 implementation requires coordination with a variety of regulatory agencies primarily because of the potential for take of the Threatened Desert Tortoise as defined in the Endangered Species Act (ESA - 1974). Take has a legal definition in the ESA and can be summarized as any human activity that causes harm to desert tortoises or their habitats in a very broad sense. DTK9 work may be allowed to occur with appropriate adherence to regulations and acquisition of appropriate permits from regulatory agencies in the federal, state and local governments. Regulations and permitting described herein are focused not only on human and dog activities that potentially result in the illegal take of the desert tortoise but also entering lands that have additional regulations associated with the administrative agencies with jurisdiction over particular land parcels where DTK9 activities are planned to occur. Permit applications for any purpose can take as long as one year to acquire, and insufficient lead time to complete the permitting process could result in the delay or postponement of planned activities

involving DTK9 teams. Because this is a relatively new process, it should be expected that the permitting process might be especially arduous and the maximum time available should be invested by parties planning to engage in permitting for DTK9 activities.

Table 17. Required permits for the implementation of DTK9 teams.
This list incorporates all of the potential permit sources that were encountered during this project and lists others that may exist or be originated subsequent to this report.

Agency	Required Permit	Law / Regulation
Federal agency		
United States Fish and Wildlife Service	Threatened Species Permit	ESA of 1973
State wildlife agencies		
California Department of Fish and Game	Scientific Collecting Permit	California Endangered Species Act
Nevada Department of Wildlife	Scientific Collection Permit	Sect. 503.080.2 Nevada Administrative Code
Utah Division of Wildlife	Endangered Species Recovery Permit	Utah Administrative Code Title 23: Rule 657-3-25
Arizona Game and Fish Department	Scientific Collecting Permit	Arizona Revised Statutes. Title 17, Game and Fish
U.S. Department of Interior agencies		
Bureau of Land Management	Cooperative Agreement	Code of Federal Regulations, Title 43 (Public Lands: Interior)
National Park Service	Scientific Research and Collecting Permit	U.S. Code of Federal Regulations, Title 36
National Wildlife Refuge	Research Permit	Code of Federal Regulations, Title 50 (Wildlife and Fisheries)

The potential for take is always present when working with live desert tortoises and their habitats with or without the use of dogs. Take could occur at any time when human personnel are working in an official capacity as a DTK9 team during training, or the implementation of a DTK9 program, even in the absence of dogs. Vehicular accidents are a primary concern when personnel are traveling in occupied desert tortoise habitat. Training activities also increase the probability for humans to take desert tortoises by stepping on small unseen individuals. Just as people are taught not to directly or inadvertently harm tortoises, dogs are taught not to touch tortoises, and just as people make mistakes, so are dogs imperfect. People may inherently show restraint toward handling tortoises in the absence of such education, but dogs will not. For these reasons there exists an additional level of risk when interfacing untested (i.e., untrained or insufficiently trained) dogs with tortoises. Although we found that our testing process yielded teams that could operate in proximity with tortoises safely, the addition of dogs to surveys inherently adds a level of risk of harming tortoises. The risks stem from the presence of dogs, albeit relatively small based on our demonstration results, and due to the necessity of the handler to share focus on multiple tasks simultaneously—watching their own foot placements, watching the dog's foot placements, watching dog's general body movements, and maintaining search lines. These are all elements that are required to maintain permit compliance and minimize if not avoid unnecessary take.

Any activity that could purposefully or inadvertently result in habitat destruction would also be considered take and be restricted by permits acquired through agencies. Purposeful habitat destruction would include activities such as driving or parking on previously untrammeled habitat in areas where such activities are restricted. These few examples are by no means comprehensive, and for this reason all personnel directly involved with hands-on activities with desert tortoises must be listed by name on federal and state endangered species permits.

The DTK9 demonstration ESTCP RC-200609 has provided a benefit to the establishment of a more widespread program involving DTK9s for tortoise searches because the permits that were required for all phases of the demonstration plan provide a template for considerations involved in issuing such a permit. Furthermore, during the course of this multiyear development of the demonstration, the permit was revised to account for aspects of the permitting that resulted in irresolvable management issues, were irrelevant to the implementation activities, or were simply logistically unfeasible. Therefore, future permitting applications will benefit from previous permits by using those templates.

9.2 DECISION-MAKING FACTORS FOR END USERS

In a large part, this program was designed to consider and remedy potential end-user concerns and to address decision-making considerations. Acceptance of the certification standard (Cablk and Harmon, 2011) developed as part of this report must be complete prior to the implementation of the program. In spite of the intensive planning involved in writing the certification standard as a stand-alone document, which remains in discussion with the permitting agencies, several factors are not under the control of any entity (e.g., environmental conditions) and thus a discussion of these factors can assist potential DTK9 users in making well-informed decisions in planning activities.

It is important to recognize that placing dogs in desert tortoise habitats automatically sends up red flags for the constituents (e.g., the public and agency personnel) of regulatory agencies due to the potential for the dogs to interact with tortoises and their habitats in negative ways. Dogs are innately driven to explore the possibility of many wild animals as prey species and predatory behaviors may be expressed in their presence such as lunging at, digging around, chasing and/or biting potential prey items. The DTK9 program was developed with a keen awareness of this sensitivity and its developers have gone to great lengths to alleviate the concerns of regulatory agencies. For example, a research project was specifically designed and implemented during the early development of the DTK9 program to address many of these concerns (Heaton et al., 2008). Specifically, Heaton et al. demonstrated that wild canines (e.g., coyote and fox) were not attracted to sites where DTK9 teams recently worked, and there was no detectable harm to tortoises above background levels for at least 2 years after an intensive DTK9 survey was implemented. Although it is unlikely that all such fears will be alleviated to the satisfaction of all involved individuals, scientific literature developed as a result of RC-200609 provides an avenue to facilitate permitting DTK9 implementation.

Regardless of preparation, when DTK9 teams work in desert tortoise habitat there is potential for unintentional harm by dogs, humans, and vehicles by merely trampling small tortoises (e.g. <100 mm carapace length). The other primary concern for tortoises and their habitats during implementation includes the potential of aggressive behaviors toward tortoises, which could

result in burrow destruction, trampling of tortoises or actually having a tortoise injured by overly enthusiastic finds or actually being bitten. The DTK9 training program included extensive instruction designed to avoid such encounters, but the fact is that dogs in association with tortoises provide opportunity for the unexpected and thus permits are required according to appropriate regulations. All phases of the DTK9 program development focused on safety for the tortoises and their habitats as a priority as a means to reduce the probability of harm. The emphasis of safety is documented throughout all documents related to RC-200609.

The endusers are in partnership with a group of agencies because any entity that decides to implement a DTK9 program will minimally be required to coordinate these activities with the USFWS and appropriate state wildlife agency. The primary concern of the regulatory wildlife management agencies will be the health and safety of desert tortoises that are involved in DTK9 surveys and to minimize stress and injury to those animals. Therefore, the primary concern of the enduser will be to work with well-trained and preferably highly experienced DTK9 teams. Several scenarios are provided for consideration by potential endusers. These scenarios hold true for use of both DTK9 teams and human survey teams.

Scenario 1 - Permits must be applied for up to 1 year prior to activities. However, the availability of trained and previously permitted DTK9 teams may be limited due to the initial costs of investing in the training. Therefore, permit applications may be applied for without naming individuals and their credentials for inclusion in field activities. These details must be considered and worked through with permitting agencies during preliminary contacts.

Scenario 2 - Should field work not be implemented due to project failure, permit complications, or biological factors such as large-scale tortoise inactivity, it will affect the contractor and project initiators. Tortoise activity is dependent on environmental variables (Zimmerman et al., 1994, Nussear and Tracy 2007, Inman et al., 2009) such that some spring seasons are unlikely to be conducive to finding tortoises adequately. In these cases, fieldwork may be cancelled thus creating contracting conflicts, which should be accounted for in advance of issuing a contract for work.

Scenario 3 - Training should probably be conducted in the active season prior to project implementation for new DTK9 teams. This is because the window of time when DTK9 work can be conducted is limited to the spring and fall due to temperature restrictions. DTK9 teams should plan for a brief but intensive refresher just prior to actual DTK9 implementation and this must be accounted for in permitting and contracting.

9.3 PROCUREMENT AND RELATED ISSUES

Equipment such as technological hardware is a relatively minimal investment for those wishing to procure DTK9 teams to search for desert tortoises. Those interested in fielding DTK9 teams will need to make a choice between contracting professional DTK9 teams (i.e., off-the-shelf) and developing teams in-house.

The DTK9 program developed under RC-200609 has functioned as a program using contractors and thus most similar to an off-the-shelf type of project. In this way, several of the important considerations regarding the development of the DTK9 program were basically designed for the

off-the-shelf type of program. The primary consideration for developing an in-house program is the amount of time during which it is impractical to field the K9s. This downtime would likely reduce the cost-effectiveness of such a program unless the DTK9s were trained for other activities that could be conducted during non-tortoise surveying time periods. Training the teams to search for other sensitive plants or potentially animals during the parts of the year when they are not needed to search for tortoises is one way to increase the cost-effectiveness of such a program. Certainly there must be several species that require similar types of data to that used for desert tortoise surveys among the U.S. military installations.

Thoughtful consideration and a full understanding of detection dog training and deployment is necessary before committing to train a dog for multiple target odors to ensure optimal performance is maintained for each target species. A multispecies approach is beyond the scope of this program at this time and was not evaluated as part of this project. However, several of the DTK9 teams that fielded as part of this program work throughout the entire calendar year on multiple wildlife scat targets or for law enforcement search and rescue activities.

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APPENDIX A

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